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Intra-articular anaesthesia for lameness diagnosis in the dog

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‘Life is as dear to a mute creature as it is to man. Just as one wants happiness and fears pain, just as one wants to live and not die, so do other creatures.’

The Dalai Lama

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LIST OF ABBREVIATIONS

AA=	Anaesthetic arthrography
ACP=	Acepromazine
ACPM=	Acepromazine + methadone
BSA=	Body surface area
CT=	Computed Tomography
g=	Greater tubercle
h=	Humeral head
IA=	Intra-articular anaesthesia
IM=	Intramuscular
IV=	Intravenous
K=	Kappa
MCD=	Medial compartment disease
MED=	Medetomidine
ml=	Mililiter
Mm=	Milimeter
MRI=	Magnetic Resonance Imaging
N=	Negative
NRS=	Numerical rating scale
OA=	Osteoartritis
OCD=	Osteochondrosis dissecans
P=	Positive
PABA=	Para aminobenzoic acid
SD=	Standard deviation

PREFACE

Joint problems as cause of lameness in dogs are very common especially problems localized in the elbow joint. The exact localization and identification of the cause of lameness is essential for an effective therapy.

In many cases lameness cannot be attributed to one joint after orthopaedic and radiologic examination alone. In those cases no abnormalities can be detected on routine examinations or multiple joints are affected. In addition a radiographic abnormality does not prove it is the cause of lameness in a particular dog. This is in particularly in older dogs where clinical and radiographic changes may be ambiguous.

Over the years different, more advanced, methods were developed to help the clinician in finding the exact localization of the dog's lameness. Computed tomography and magnetic resonance imaging are more sensitive than radiography for the detection of jointproblems. Bone scintigraphy has also been used for the localization of occult lameness in dogs and, more specifically, regarding the diagnosis of medial coronoid disease in dogs.

A major disadvantage of scintigraphy is the necessity of radionucleotides and specialized staff, rendering routine scintigraphy to be available in specialized centers only.

This PhD thesis explores the use of intra-articular anaesthesia as a diagnostic tool in occult lameness in dogs. In a first part a review of the human and veterinary literature is given on local anaesthetics and their intra-articular use. In a second part the sedation protocol prior to intra-articular anaesthesia in discussed. In the following parts intra-articular anaesthesia is studied in different joints and more in detail in the elbow and shoulder of the dog.

A REVIEW OF THE HUMAN AND VETERINARY LITERATURE ON LOCAL ANAESTHETICS AND THEIR INTRA-ARTICULAR USE.

RELEVANT INFORMATION FOR LAMENESS DIAGNOSIS IN THE DOG.

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SUMMARY

Lameness in dogs is often a diagnostic challenge. In many cases it is difficult to determine the exact localization of lameness because of the absence of palpable changes, or because of unreliable pain response due to high pain tolerance, stress or aggression of the dog. In horses and humans, intra-articular administration of local anaesthetics is commonly used for diagnostic purposes. In this review, information from human and veterinary studies on different local anaesthetic agents and their application for diagnostic intra-articular anaesthesia is given. Based on this information a protocol for diagnostic intra-articular anaesthesia in the dog can be developed and evaluated in future studies.

INTRODUCTION

Lameness in dogs is a common clinical problem and is often a diagnostic challenge. Localisation and identification of lameness is commonly based on history, clinical and radiographic findings. However, in many cases it is difficult to determine the exact localisation of lameness because of the absence of palpable changes or because of unreliable pain response due to high pain tolerance, stress or aggression of the dog.
Scintigraphy has been described to be helpful in identifying the localisation of lameness in dogs (1). It is a sensitive method, but in case of multifocal uptake no definitive diagnosis can be made. A major disadvantage of scintigraphy is the limited access for routine use, since it is only provided in specialised centres.
In horses and men, intra-articular administration of local anaesthetics is commonly used for diagnostic purposes because of their simplicity, safety and low cost. The principle is simple; local anaesthesia is injected into the joint, the anesthetic is absorbed and sensation (including pain) in the area is temporarily blocked.

Most equine practitioners commonly use diagnostic anaesthesia to determine the source of lameness. In horses nerve blocks as well as joint blocks are used to identify the source of lameness. Local anaesthesia injected in different joints helps to isolate the source of lameness when inspection and palpation are inconclusive (2,3,4). Intra-articular anaesthesia can temporarily resolve lameness caused by a variety of lesions. Lameness caused by synovitis, bone and cartilage fragments; intra-articular ligament damage and eroded cartilage can all be improved by performing a joint block (3).
In men intra-articular injections has been used in many joints to aid in diagnosis and predict surgical success. Intra-articular injections of local anaesthetics has been used as an aid to differentiate shoulder pain (5), to diagnose chronic wrist pain (6), for the localisation of foot and ankle pain (7), for the differentiation between hip and spinal pathology (8,9) and for the evaluation of hip disorders prior to surgery (8;10-15).

At this point no simple diagnostic test other than scintigraphy has been described to identify or confirm the source of lameness in dogs (16). Therefore we propose intra-articular anaesthesia as an alternative method to localise lameness. The use of diagnostic intra-articular anaesthesia as an aid to identify lameness in dogs has poorly

been reported. In contrast, the use of local anaesthetics for perioperative pain relief in dogs is well known and generally accepted (17). Lameness examination in dogs usually allows confining the problem to one or two joints based on the history and the clinical and radiographic examination. However, the confirmation of the localisation in the suspected joints is often required because of absence of clinical and/or radiographic changes, as well as in cases were changes our found in more than one joint of the same leg. Although the protocol for lameness diagnosis and intra-articular anaesthesia in horses and men is different, important information on products, toxicity, technique and interpretation can be relevant for developing a protocol for diagnostic intra-articular anaesthesia in the dog.

AGENTS SUITED FOR INTRA-ARTICULAR ANAESTHESIA

Opioids and local anaesthetics are the two groups of products that can be applied for intra-articular pain relief.

Since the discovery of opioid receptors on peripheral nerves and joints in the later 1980's several studies have described the analgesic effect of opioids (mainly morphine) after arthroscopy or joint surgery in men (18). Opioids exert their analgesic effect by interacting with specific opioid receptors (mu, sigma, kappa, delta) located both centrally (brain and dorsal horn of spinal cord) and peripherally (joint capsules, pleural membranes and organ capsules) (19). The augmentation of opioid receptors in joints during chronic (20) and acute inflammation (21) indicates the potential use of opioids in painful joints. In men a study showed that the use of intra-articular morphine as postoperative analgesic is not contra-indicated and does not appear to have a deleterious effect on articular cartilage (22). However, in dogs as well as in men the efficacy of intra-articular morphine has been questioned (23,24). In dogs, when compared to bupivacaine, morphine seems to provide some analgesia lasting at least 6 hours, but not to the extend of intra-articular bupivacaine (25). In men a study showed that intra-articular morphine produced a good analgesic effect only after three hours (26). The opioid morphine seems to produce good analgesia with little adverse side effects when used intra-articularly in horses (27). Because of their delayed onset and doubtful effectiveness in dogs as well as in men, opioids are not considered

suitable for diagnostic intra-articular anaesthesia and will not be further described in this paper.

Local anaesthetics reversibly bind sodium channels and block impulse conduction in nerve fibres. This interruption of neural transmission after e.g. intra-articular injection effectively prevents or reduces pain during and after surgery (28). Local anaesthetics have been used since 1860 and evolution over years resulted in different products with different properties and applications. The older products are ester-linked, the newer products are amide-linked. The nature of linkage has an effect on the chemical stability and the route of metabolism. Ester linked local anaesthetics (cocaine, procaine) are readily hydrolysed by plasma cholinesterase and have a short half-life when stored in a solution without preservatives. Amide-linked local anaesthetics (lidocaine, mepivacaine, bupivacaine) are very stable and rely on enzymatic degradation in the liver. Nowadays amino-ester local anaesthetics are rarely being used because of hypersensitivity reactions (see lower: 'allergic reactions'). Cocaine was the first local anesthetic, in use since 1860. Because of its toxicity and danger for addiction, the search for other local anaesthetics was started (28). In 1905 procaine was developed as the first non-toxic prototype of amino-ester local anaesthetics (28). It was the first synthetic local anaesthetic agent available for clinical application. It is not frequently used these days because it is less effective than the other local anaesthetics (2).

The next milestone in local anaesthetic synthesis was lidocaine, the prototype for all subsequent amide-type local anaesthetics. Lidocaine is characterized by a rapid onset but a short duration (28). Despite a marked local irritation in some horses, lidocaine was commonly used for diagnostic local anaesthesia for several decades (end '40 - mid '80) (29). Nowadays, mepivacaine is the most widely used local anaesthetic for diagnostic purposes in horses because it is less irritating and longer lasting then lidocaine (2,30). This product has a rapid onset and intermediate duration of action, a high therapeutic index and limited tissue reaction. In men, bupivacaine was the most commonly used anaesthetic for diagnostic intra-articular anaesthesia for years. It has a slow onset and long duration of action. The therapeutic margin of safety of bupivacaine is much narrower compared with lidocaine and its use is therefore largely discontinued in human medicine. Ropivacaine and levobupivacaine are the most

recently developed local amino-amides with a slow onset and long duration of action. Those products are similar to bupivacaine and have been developed as safer alternatives (31,32). Both are used intra-articularly in men and horses for post-operative pain relief (33,34). Most local anaesthetics are available with or without addition of epinephrine. The addition of epinephrine prevents diffusion to the surrounding structures by vasoconstriction and therefore decreases the potential systemic toxicity. However, preparations of local anaesthetics with epinephrine have a lower pH than plain solutions. A lower pH potentially slows down the onset of action of the local anaesthetics because of the decreased amount of free non-ionised base available for diffusion through the axonal membrane. Additionally, vasoconstriction can cause local tissue necrosis (2). Epinephrine also increases the potential risk of cardiac arrhythmias, although no problems have been reported when given in conjunction with lidocaine in dogs (35). In dogs, the properties of different local anaesthetics and their intra-articular use for perioperative pain relief have been described and are summarized in Table 1 (17,36). The described products are limited to the local anaesthetics used for diagnostic purposes in men and/ or horses.

Table 1 Onset time, duration of action, relative potency, clinical and toxic doses of local anaesthetics for peripheral block procedures in dogs.

Anaesthetic drug	**Relative potency***	**Dose with epinephrine (mg/kg)**	**Dose without epinephrine (mg/kg)**	**Toxic dose (mg/kg)**	**Onset of action (minutes)**	**Duration of action (minutes)**
Mepivacaine	2	7	5	29	5-10	120-150
Lidocaine	2	7	5	10-20	10-15	60-120
Bupivacaine	8	3	2	3,5-4,5	20-30	150-360

'Dose' refers to the intra-articular dose commonly used for pain relief in dogs.

'Toxic dose' is the IV dose that induces convulsions in dogs.

**Potency is relative to procaine.*

TOXICITY

Toxicity mainly results from accidental intravascular injection rather than because of an overdose. When a careful technique and an appropriate dose are used local anaesthetics rarely induce harmful side effects. Intra-articular administration of local anaesthetics has a low risk for systemic absorption and toxic side effects (37). In dogs we expect that only the most suspected joint will be injected for localisation of the lameness. As such only a small volume of local anesthetic is required, which makes toxicity very unlikely. Because most local anaesthetics are amide compounds mainly metabolized in the liver, patients with hepatic disease may be more susceptible to adverse reactions. Nevertheless, in small dogs, even when healthy, the dose of a local anesthetic should always be calculated carefully.

Systemic reactions to local anaesthetics involve primarily the central nervous system and the cardiovascular system (Table 2). In general the central nervous system is more sensitive to local anesthetic toxicity than the cardiovascular system (38).

Central nervous problems occur usually before cardiovascular signs, with the exception of bupivacaine which is far more cardiotoxic than the other local anaesthetics (39). Shivering, muscle twitching and tremors are the first signs of central nervous system toxicity. If larger doses are given, convulsions are followed by unconsciousness, coma, and respiratory arrest (40). More potent local anaesthetics produce seizures at lower blood concentrations and lower doses compared to less potent local anaesthetics. Hence the more potent bupivacaine induces central nervous toxicity at a lower dose than the less potent lidocaine (Table 1).

The effects of local anaesthetics on the cardiovascular system are mediated through direct actions on the heart and vascular system and on the autonomic nervous system. High plasma levels typically depress the heart and may result in bradycardia, arrhythmias, hypotension, cardiovascular collapse, and cardiac arrest (36). In anesthetized dogs the lethal dose was the lowest for bupivacaine (+/- 11 mg/kg), lidocaine was lethal at +/- 28 mg/kg and the least toxic was mepivacaine at a dose of +/- 33,3 mg/kg. (41,42). The intense cardiac depression produced by bupivacaine

can be difficult to treat (43). The comparison of the toxic effect in awake and anesthetised dogs showed that the lethal cardiovascular dose of lidocaine and bupivacaine is about three times higher than the dose at which convulsions are produced (42). This supports the conclusion in dogs that the central nervous system is the primary target organ for local anesthetic toxicity (38).

Table 2 Categories of local anesthetic toxic reactions

Systemic	**Localised**
Central nervous system: - shivering, muscle twitching, tremors, unconsciousness, coma, and respiratory arrest Cardiovascular system: - arrhythmias, hypotension, cardiovascular collapse, and cardiac arrest Methemoglobinemia: - fatigue, weakness, dyspnea and tachycardia (Allergic reactions)	Tissue toxicity: - cell necrosis (Allergic reactions)

Some anaesthetics, particularly benzocaine and to a lesser extent procaine and lidocaine, are associated with haematologic effects, namely methemoglobinemia (28). As methemoglobinemia reduces the amount of hemoglobin that is available for oxygen transport, this side effect is potentially life threatening. Concentrations between 20 and 50% cause fatigue, weakness, dyspnea and tachycardia. Treatment consists of oxygen therapy and IV methylene blue (38).

Allergic reactions to local anaesthetics are the result of sensitivity to the active product itself or to the preservative. Those allergic reactions are very rare in dogs and often misdiagnosed after accidental intravenous injection (28). Ester-linked local anaesthetics (e.g. procaine) are more likely to produce allergic reactions than the amide-linked anaesthetics. This is due to a sensitivity to their metabolite, para-aminobenzoic acid (PABA), which is a common allergen (36). Anaphylaxis due to amide-linked local anaesthetics (e.g. lidocaine, bupivacaine, mepivacaine) is much less common (36). Some reactions may result from hypersensitivity to methylparaben, a preservative whose chemical structure is similar to that of PABA. All standard local

anaesthetics with epinephrine (vasoconstrictor) contain a preservative. The preservative is necessary to protect the vasoconstrictor against oxidation (39). Most local anaesthetics are available without preservatives.

In vitro tests have shown that lidocaine as well as bupivacaine is cytotoxic for human and bovine articular chondrocytes. Those cytotoxic effects are dose- and time-dependent (44,45). In contrast, an older study showed that diluted bupivacaine had no irreversible effects on articular cartilage (46). The newer ropivacaine is significantly less toxic then bupivacaine on human articular cartilage (47). The effect of preservatives on articular cartilage is unknown. Therefore preservative-free local anaesthetics are preferred if used intra-articularly (15). It has been proven that lidocaine as well as mepivacaine causes a moderate increase in synovial fluid cellularity. A comparison of synovitis after intra-articular injection of lidocaine and mepivacaine applied in equine carpal joints did not show any difference between lidocaine and mepivacaine (48). Another study has shown mepivacaine to be significantly less reactive then lidocaine (49). Local irritation and necrosis of muscles and skin have been observed after administration of lidocaine, bupivacaine and mepivacaine (40). However, experience in horses learned that swelling and oedema in the area of injection is minimal when using mepivacaine (50) .

INJECTION TECHNIQUES

Potentially any joint can be injected with local anaesthetics. An intra-articular injection can be considered painful, as it is an invasive procedure, although limited to a single puncture. Most horses tolerate the intra-articular injection extremely well (50), but to facilitate the procedure sedation may be necessary in nervous animals.

Sedation itself can interfere with the lameness evaluation because sedative drugs may have an analgesic effect of their own. Therefore a careful selection of the sedative drug and dose should be made (51). A bleb of a local anesthetic can be deposited subcutaneously to prevent a defensive reaction (2,52). In human medicine skin anaesthesia does not seem to be necessary (53), unless using a large-diameter needle (e.g., 18-gauge). In animals the area to be infiltrated should be clipped and cleansed with an appropriate antiseptic solution (52). In a study of Hague et al. (54) skin bacterial flora was evaluated before and after aseptic preparation of clipped and non-clipped arthrocentesis sites in horses. Each site was aseptically prepared with povidone iodine and 70 % alcohol. The results suggested that aseptic preparation of the skin could be accomplished without hair removal, because the presence of hair does not appear to inhibit antiseptics to reduce bacterial load to an acceptable level. However, hair removal can be helpful for better orientation of the puncture site. Careful palpation of the anatomic landmarks is necessary to increase success on the first attempt. In horses it was proven that repeated arthrocenthesis increased joint fluid cellularity, so multiple injections should be avoided if possible (2).

The size of the needle depends on the depth and size of the joint and the preference of the clinician. In dogs a 25mm, 22-gauge needle and a 3 ml syringe are used most commonly. A 55- to 75 mm, 22-gauge spinal needle may be required for the hip joint in large or obese dogs and a 23- or 25- gauge needle may be used for distal joints and for small dogs (55). In all species, synovial fluid is retrieved before injecting the local anesthetic into the joint. This confirms the intra-articular position of the needle and allows to examine the synovial fluid (52). Despite correct needle placement, failure to aspirate synovial fluid from a joint can occur because of different reasons: the needle tip may touch cartilage or synovium or can be obstructed by villi or joint debris

during aspiration. In other cases the volume might be minimal or the fluid too viscous (52,56).

The injection of the local anesthetic into the joint space should not offer any resistance. If resistance is experienced, the needle tip may be inserted in a ligament, tendon or in the articular cartilage. In that case, the needle should be redirected or slightly withdrawn until minimal resistance is encountered (57). There are several ways to ensure the correct intra-articular injection: backflow after injection, palpable distension of the joint, injection of air or contrast medium followed by radiography or fluoroscopy or injection performed under fluoroscopic or ultrasonographic control (7,12).

When a contrast product is used to check the intra-articular position of the needle, it can be injected before or together with the local anaesthetic. It is important to inject a minimal amount of contrast fluid in order to avoid overfilling the joint and injection of an insufficient amount of the local anaesthetic (11). When inserting the needle, care must be taken to avoid injection into a vascular structure to prevent systemic side effects. If blood is aspirated, the needle should be redirected (57).

The local anaesthetics dosage depends on the patient's size and in particular the size of the joint. It is important to apply the minimal effective volume of the local anaesthetic (52). A large amount will enhance leakage of the local anesthetic from the joint into the peri-articular tissue, resulting in a reduced precision in localisation of pain (58). At the same time, a minimal amount will minimize the risk for irritation and toxicity. If the volume is too small, anaesthesia of the area of pain will be insufficient leading to a false negative response. Examples of volumes used in horses are 10 ml in an elbow joint and 20 to 35 ml in a shoulder joint (52). Based on volumes injected for contrast studies in average-sized canine shoulders an optimal volume of 2 to 4 ml is indicated (59). If preservative-free solutions are used, an opened bottle should be discharged or in some cases resterilised for later use (52).

INTERPRETATION OF THE EFFECT OF INTRA-ARTICULAR ANAESTHESIA IN HORSES AND MEN AND ITS LIMITATIONS

In horses adequate anaesthesia can be achieved in as little as one minute in some cases, but often 10 to 15 minutes are required before the anaesthesia takes full effect. It is therefore necessary to observe the patient over a sufficient period of time to assess the effect of the local anesthetic (30). Andreen et al. (1994) showed that mepivacaine alleviated the induced lameness in horses after 5 minutes and the lameness reoccurred after 50 minutes (60).

The evaluation of the effect of intra-articular anaesthesia can be difficult. If the horse is inconsistently or only slightly lame before the block, it is virtually impossible to assess any improvement of the lameness afterwards if there is only partial alleviation (30). In horses the rate of difficulties of interpretation of the results of diagnostic anaesthesia is estimated on five percent (2). Some horses simply don't respond after appropriately applied diagnostic anaesthesia procedures. Even confirmed pathology may not predictably respond to the intra-articular anaesthesia and cause false negative results. False negative test, in other words the failure of intra-articular anaesthesia to reduce joint pain and lameness, has different origins: the injected volume might have been too small, pain is originating from subchondral bone with intact cartilage, too severe intra-articular damage, pain might not be confined to the inner part of the joint (61). If intra-articular anaesthesia of a joint is not effective, another joint can be injected. If the pain cannot be localized using intra-articular anaesthesia, other diagnostic methods should be performed to find the source of lameness. Scintigraphy can be useful (1,62) as well as CT scan, MRI or arthroscopy (63). Reasons of false positives tests are misinterpretation because of discrete lameness or leakage of the local anesthetic from the joint into the peri-articular tissue resulting in a reduced precision in localisation of pain (58). In men, the patients themselves often make their own interpretation. The patient records his pain score over a period of time following the injection. Those pain scores are used for surgical treatment decision (15).

CONCLUSION

Intra-articular anaesthesia is an accessible and well-accepted technique for localising pain arising from joints in men and horses. The possibilities of this relatively simple technique should encourage veterinary surgeons to apply local anaesthesia in dogs as well. However, the technique should be used with care and one should be aware of some limitations: the technique should be correct and some disorders might not be responsive to local anaesthesia. In dogs, problems related to incorrect injection because of the small joint size or uncooperative behaviour can be expected and proper restraint, either physically or under sedation, is indicated. A non- or low-irritant local anesthetic should be used to minimise the risk of any post injection reaction.

Mepivacaine seems the most appropriate product for diagnostic intra-articular anaesthesia in dogs: it has a fast onset of action and is a safe product, considering the successful use in the horse since many years. It appears to cause less irritation than lidocaine for intra-articular injections when used in horses. Based on the information on local anaesthetics and their use in horses, men and dogs, we suggest following protocol for lameness diagnosis in the dog: 1 to 4 ml of mepivacaine injected in the most suspected joint with a 25mm, 22-gauge needle depending on the size of the dog and the kind of joint. The dog should be walked over a time period of minimum 15 minutes to assess the effect of the local anesthetic. Further studies are currently being performed to evaluate and adapt the protocol for different joints and to determine the effect in correlation with different joint pathology. Those results will be published in following articles.

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SCIENTIFIC AIMS

The diagnosis of lameness in dogs is based on the anamnesis, the clinical and the radiographic examination. The localization of the problem is the first step in the diagnosis and is deduced from inspection and palpation. Further identification of the disorder is obtained examination of the locomotion and by performing radiography, eventually supplemented by other imaging techniques. In some dogs the localization of the problem is very difficult because of uncooperative behavior or limited clinical findings. In those cases, additional methods are necessary to localize the problem. Therefore the general aim of this study is to evaluate intra-articular anaesthesia as a diagnostic aid for lameness examination in the dog. In the review of the literature on the use of diagnostic intra-articular anaesthesia in man and horse and of the postoperative use of local anaesthetics in the dog, we reveal the possible side-effects and complications and determine the most suitable product, dose and technique.

The first aim is to determine the effect of sedation prior to intra-articular anaesthesia. Indeed, most dogs need sedation before a joint can be punctured, but lameness should of course not be eliminated by sedation. The goal of this study is to demonstrate that two sedation protocols have minimal influence on the degree of lameness, allowing the use in further studies.

The second aim is to evaluate the application of intra-articular anaesthesia under clinical circumstances. By analyzing a large series of patients, the indications and limitations can be deduced.

The third aim is to investigate the effect of intra-articular anaesthesia on different types of medial coronoid disease. This should allow determining if intra-articular anaesthesia can eliminate lameness caused by discrete lesions that are difficult to diagnose based on the clinical and radiographic examination.

The fourth aim is to combine intra-articular anaesthesia with arthrography, to detect and identify shoulder lameness. The goal of this study is to evaluate the quality of the images and the effect of this combined diagnostic test.

EVALUATION OF TWO SEDATION PROTOCOLS FOR USE PRIOR TO DIAGNOSTIC INTRA-ARTICULAR ANAESTHESIA IN LAME DOGS.

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SUMMARY

The purpose of this study was to assess the influence of two sedation protocols on the grade of lameness in dogs

Fifty lame dogs were allocated to one of two sedation protocols. Group ACPM (n=25) was sedated with acepromazine and methadone. Group MED (n=25) was sedated with medetomidine and reversed with atipamezole. Each dog was evaluated for lameness before and after sedation using videotapes. Four experienced clinicians allocated global lameness scores before and after sedation to each dog using a numerical rating scale.

In 80% of the dogs in group ACPM and in 72% in group MED lameness was not affected by the sedation. In 12% of the dogs in group ACPM and 20% of the dogs in group MED the observers noticed an increase of lameness of 1 or 2 grades on a scale of 0 to 10. In 8% of the dogs in both groups lameness decreased with 1 grade.

A possible diagnostic test for investigation of obscure lameness is intra-articular anaesthesia. Sedation is necessary to allow intra-articular injection. This study provided evidence that the effect of sedation with the proposed protocols on the grade of lameness is negligible.

INTRODUCTION

Localization of lameness in dogs can be challenging. In many cases it is difficult to determine the exact site of lameness because of absence of palpable changes or because of unreliable pain response due to high pain tolerance, stress or aggression. Since lameness in dogs is commonly associated with joint pain, a test that eliminates this pain could confirm the intra-articular localization of lameness.
Intra-articular anaesthesia as a diagnostic tool is commonly used in horses and humans but has poorly been described in dogs (Houlton 1994, Van Vynckt and others 2010). In most horses, elevating a limb or using a twitch is sufficient to inject the joint safely. Chemical restraint is only necessary in uncooperative horses. A study of the effect of detomidine on the locomotion pattern in lame horses showed that a low dose of detomidine (10 μg/kg) provided an appropriate sedation without altering the grade of lameness (Buchner and others 1999). However some ataxia may interfere with the assessment of changes in lameness following diagnostic anaesthesia, especially in horses with subtle lameness. Antagonization with atipamezole (100 μg/kg) attenuated most of these effects and allowed the assessment of intra-articular anaesthesia. Another study showed no significant changes on gait evaluation induced by sedation with xylazine (Kramer and others 2000).

In most dogs, sedation is necessary to facilitate handling and to allow correct and safe arthrocentesis (Clements 2006). In order to evaluate the effect of local anaesthesia, the dog needs to ambulate before and after the intra-articular injection. A positive response to intra-articular anaesthesia is defined as a decrease or elimination of lameness. This indicates that pain arises from the injected joint and helps the clinician to concentrate on that particular joint for further diagnostic work-up. However, sedation of the dog could influence the grade of lameness because of analgesic properties inherent to the sedative drugs and may interfere with the effect of the intra-articular anaesthesia.

Two types of sedation commonly used in clinical practice are α2-agonist- and neuroleptanalgesic-based protocols. Medetomidine is a potent α2-adrenoceptor agonist which produces dose-related sedation and analgesia in the dog (Vainio and

others 1989). A dose as high as 40 μg/kg administered by intramuscular (IM) injection is required to produce a reliable sedation while lower doses can be used for intravenous (IV) administration (Clarke and England 1989, Kuusela and others 2000). Additional advantages of α2-adrenoceptor agonists include their potent analgesic properties and their potential for fast reversal of sedation and analgesia by atipamezole, a highly specific α2-adrenoceptor antagonist (Clarke and England 1989, Vaha-Vahe 1990), which enables a rapid and sudden recovery. Acepromazine is a commonly used neuroleptic agent and induces tranquilization without analgesia, causing slowing of the gait (Hall and others 2001). Sedation with acepromazine is generally less reliable as compared to sedation with α2-adrenoceptor agonists, especially if the dog is already agitated (Brock 1994). However, the quality and reliability of sedation with acepromazine can be improved by a combination with an opioid (neuroleptanalgesia) such as methadone (Monteiro and others 2008, Monteiro and others 2009).

The influence of sedation on lameness in dogs is largely unknown. The objective of this study was to examine the influence of two types of sedation. Our hypothesis was that the proposed sedation protocols do not cause a clear decrease of lameness thus allowing the application of intra-articular anaesthesia and the interpretation of its effect.

MATERIALS AND METHODS

Sedation Protocols

Fifty dogs presented with lameness and undergoing lameness examination were prospectively evaluated. The dogs were of different breeds with a mean weight ± SD of 34,89 ± 11,37 kg and mean age ± SD of 47,98 ± 30,73 months. Thirteen dogs were presented with hind limb lameness and 37 with front limb lameness. All were videotaped when walking and trotting away from and towards the video camera and laterally while turning. Video sequences (20-60 seconds) were recorded before and after sedation. The dogs were assigned to two sedation groups depending on a possible same-day-surgery. This selection criterion was based on ad random appointments depending on owner and surgeon schedule.

ACPM protocol: Dogs of group ACPM (n=25), scheduled for same-day-surgery, were sedated with acepromazine (0.01 to 0.02 mg/kg) (Placivet®, 20 mg/mL, Codifar, Belgium) in combination with methadone (0.1 to 0.2 mg/kg) (Mephenon®, 10 mg/mL, Denolin, Belgium) mixed in the same syringe and given intravenously (IV). All dogs received 0.01mg/kg and were videotaped 35 minutes after sedation. Some dogs needed a supplementary dose (total of 0,02 mg/kg) to allow manipulation or positioning on the table for radiography or intra-articular anaesthesia. In that case a second videosequence was made, which replaced the first one for lameness evaluation. Subsequently, intra-articular anaesthesia was performed in some of those dogs.

MED protocol: Dogs of group MED (n=25), scheduled for diagnostics only, were sedated with medetomidine (Domitor, 1.0 mg/mL, Orion Pharma, Finland) given IV. Dosage was based on body surface area (BSA, using 500 mcg/m^2), ranging from 25 to 53 mcg/kg. In this study, sedation was antagonized approximately 30 minutes after medetomidine using atipamezole (Antisedan, 5.0 mg/mL, Orion Pharma, Finland) given intramuscularly. Dosage was based on body surface area (BSA, using 1000 mcg/m^2), ranging from 62 to 132 mcg/kg. Practically this corresponds with half of the volume-dose of the medetomidine. Dogs of group MED were evaluated 7 minutes

after receiving atipamezole. The applicated doses were based upon approved European dosages in dogs and are used on routinely base in the author's hospital.

Data Collection

In this study, a total of four observers, blinded to the type of sedation, were asked to assign a lameness score for each individual video sequence. All observers were highly experienced in lameness evaluation. A modified numerical rating scale (NRS) was used to score each sequence. This 11-point NRS has been developed in the UK for grading lameness in horses (Arkell and others 2006, Fuller and others 2006). It is a subjective scoring system with 0 indicating that the dog is sound and 10 indicating the complete lack of use of a limb. The observers were not informed which sequence was taken before or after sedation, allowing the observers to compare both sequences of the same dog and to allocate a global score without being biased. This blinding system, in which observers were able to directly compare two video sequences, was chosen above 'complete' blinding because global scoring seems to be more reliable than individual scoring in horses (Fuller and others 2006). The global score, assigned additionally to the NRS-score, was given to each dog to illustrate a change in lameness between both sequences of the same dog: decreased < 1 grade, decreased > 1 grade, unchanged, increased < 1 grade, increased > 1 grade. Dogs were categorized as "decreased" or "increased" lameness as soon as three observers noticed a difference in lameness. The other dogs were categorised as unchanged lameness. The median grade of lameness is the mean grade given by the four observers for each dog before sedation.

In addition, video sequences of five dogs before sedation were shown twice to evaluate the intra-observer variance. A sum of differences of the NRS score of 0 would indicate that each observer's assessments had been perfectly consistent or repeatable.

The reproducibility of the assessment was measured by comparing the given NRS score for each dog before sedation with the mean score of the four observers for that particular dog.

Statistical Analysis

The incidence of change in lameness scored by the different observers was compared for both protocols using the Cochran-Mantel-Haenszel test with ANOVA general association (Mantel and Haenszel 1959).
The level of agreement between scores was measured with the kappa statistic ($\varkappa$). K measures the proportion of agreement between two scores, made by different observers, or by the same observers at different times (Cohen 1960). A $\varkappa$ value between 0,21 and 0,40 was considered fair, values between 0,41 and 0,6 were moderate, values between 0,61 and 0,80 were substantial and a value of > 0,81 was considered almost perfect (Thrusfield 2005).

Results

The 25 dogs of the ACPM group had same day surgery and the MED group had surgery a few weeks following diagnostics. All were elbow arthroscopies and cruciate ligament surgeries. Dogs of group ACPM were able to walk after sedation. The light sedation allowed manipulation and positioning on the table but at least two persons were necessary to allow radiographic examination and intra-articular anaesthesia. Three of 25 dogs needed a double dose (0,02 mg/kg) of ACP to allow intra-articular anaesthesia. Pain reactions were rare when the joint was punctured. Walking and trotting was easy and no drowsiness was noted. Dogs in group MED were heavily sedated and manipulation was easily performed by one person. Walking was not possible without antagonisation with atipamezole. Some residual drowsiness was seen seven minutes after atipamezole was given This drowsiness made the dogs walk at a slower pace and less coordinated while encouragement was needed to make them trot. Lameness evaluation was more difficult, but the observers were still able to score the dogs appropriately.

Table 1.a. Overview of the mean grades of lameness, the weight of the dogs, the lameness distribution and the global scores for each dog allocated by all observers before and after sedation **from group ACPM (acepromazine + methadone).**

Dogs	Weight	Lameness distribution	Mean lameness grade	Result
1	36	LF	1	Lameness increased (< 1 degree)
2	25	LF	1	Lameness unchanged
3	40	RF	2	Lameness unchanged
4	7	RH	3	Lameness increased (< 1 degree)
5	42	LF	3	Lameness unchanged
6*	21	RF	3	Lameness unchanged
7	45	RF	4	Lameness increased (> 1 degree)
8	48	LH	4	Lameness unchanged
9	16,5	LF	4	Lameness decreased (< 1 degree)
10	40	LF	4	Lameness unchanged
11	28	LF	5	Lameness unchanged
12	40	RF	5	Lameness unchanged
13	40	LF	5	Lameness unchanged
14*	29	RF	5	Lameness unchanged
15	32	RF	6	Lameness unchanged
16	30	RH	6	Lameness unchanged
17	23	RF	6	Lameness unchanged
18	48	RF	6	Lameness unchanged
19	48	LH	7	Lameness decreased (< 1 degree)
20*	25	LF	7	Lameness unchanged
21	30	RF	7	Lameness unchanged
22	33	LF	8	Lameness unchanged
23	24	LH	8	Lameness unchanged
24	30	RF	8	Lameness unchanged
25	50	RF	9	Lameness unchanged

LF = Left front limb, RF = Right front limb, LH = Left hind limb, RH = Right hind limb

Dogs were categorized as "decreased lameness" or "increased lameness" as soon as three observers noticed a difference in lameness.

*Dogs with an asterix *, received the double dose.*

Table 1.b. Overview of the mean grades of lameness, the weights of the dogs, the lameness distribution and the global scores for each dog allocated by all observers before and after sedation **from group MED (medetomidine antagonized with atipamezole).**

Dogs	Weight	Lameness distribution	Mean lameness grade	Result
1	37	LF	1	Lameness unchanged
2	28	LF	1	Lameness increased (> 1 degree)
3	22	RH	1	Lameness unchanged
4	31	RF	1	Lameness unchanged
5	53	LF	2	Lameness unchanged
6	33	RH	2	Lameness unchanged
7	11	LH	2	Lameness unchanged
8	40	RF	3	Lameness unchanged
9	30	LH	3	Lameness increased (< 1 degree)
10	27	LF	3	Lameness unchanged
11	53	LF	4	Lameness decreased (< 1 degree)
12	34	RF	4	Lameness unchanged
13	40	LH	4	Lameness unchanged
14	68	LF	4	Lameness unchanged
15	43	LF	5	Lameness unchanged
16	37	RH	5	Lameness increased (> 1 degree)
17	34	LF	5	Lameness decreased (< 1 degree)
18	28	LF	6	Lameness unchanged
19	25	RF	6	Lameness unchanged
20	48	RF	6	Lameness unchanged
21	31	RF	6	Lameness unchanged
22	34	RH	6	Lameness unchanged
23	41	LH	7	Lameness unchanged
24	35	RF	8	Lameness increased (< 1 degree)
25	51	LF	9	Lameness increased (< 1 degree)

LF = Left front limb, RF = Right front limb, LH = Left hind limb, RH = Right hind limb

Dogs were categorized as "decreased lameness" or "increased lameness" as soon as three observers noticed a difference in lameness.

The mean weight for group ACPM was 33,22 kg and 36,56 kg for group MED. In 80% (20/25) of the dogs of group ACPM and in 72% (18/25) of group MED, lameness was not affected by sedation. In 8% (2/25) of the dogs lameness decreased with one grade on a scale of 0 to 10 in either group. All other dogs (12% of group ACPM and 20% of group MED) had an increase of lameness after sedation with one grade, except for three dogs that had an increase of 2 grades.

Table 2. Global scores given to the dogs by the different observers, illustrating their consistency

Group	Grade difference	Number of dogs	Scored by one observer	Scored by two observers	Scored by three observers	Scored by four observers
ACPM	Unchanged lameness	20	0	1	12	7
	Decreased lameness (< 1 degree)	2	0	0	0	2
	Decreased lameness (> 1 degree)	0	0	0	0	0
	Increased lameness (< 1 degree)	2	0	0	1	1
	Increased lameness (> 1 degree)	1	0	0	1	0
MED	Unchanged lameness	18	0	4	8	6
	Decreased lameness (<1 degree)	2	0	0	1	1
	Decreased lameness (> 1 degree)	0	0	0	0	0
	Increased lameness (<1 degree)	3	0	0	1	2
	Increased lameness (>1 degree)	2	0	0	1	1

An overview of the consistency of the observers is displayed in Table 2. Out of 25 dogs in group ACPM, 20 dogs had an unchanged lameness. This was seen in 19 dogs by three or four observers and in one dog by two observers. In group MED, 18 dogs had an unchanged lameness. This was seen by three or four observers in 14 dogs and

by two observers in 4 dogs. The overall agreement in global scoring between all four observers was considered moderate: $\varkappa = 0{,}45$.

The comparison of change in lameness between both groups of sedation (ACPM and MED) was not statistically significant (p-value of 0.4320).

Table 3. Sums of the differences in NRS scores allocated to video sequences of five dogs before sedation on two occasions by each observer and the mean difference per dog as a measure of their consistency

Observer	Sum of differences of scores	Difference per dog
1	1	0,2
2	5	1
3	4	0,8
4	2	0,4

Table 4. Number of times the NRS score allocated by each observer to the 50 dogs was different from the mean lameness grade for each dog

Observer	+/- 1 grade from mean grade	+/- 2 grades from mean grade
1	15	0
2	29	0
3	23	0
4	12	7

DISCUSSION

Localization of a source of lameness in the dog is not always conclusive based on clinical examination and may require further diagnostic workup. A possible diagnostic test is the use of intra-articular anaesthesia for the localization of joint pain. Injection in a joint often requires sedation and this might influence the lameness status. This study assessed the effect of two widely used sedation protocols on lameness in dogs. With no important change in lameness and no major differences seen between both sedation protocols, we provided evidence allowing the clinicians to choose their preferred protocol for sedation prior to intra-articular anaesthesia.

Although force plate analysis is a valuable and accurate method to obtain objective data on limb loading in dogs, lameness evaluation is most often based on visual inspection by the veterinarian because of the limited availability (Quinn and others 2007). Another disadvantage is that it is difficult and time-consuming to capture enough valid (strike in centre of plate) strikes within a small range of accepted velocities. In a recent study 40 to 122 trials were necessary to obtain five acceptable trials at walk in dogs with clinical lameness (Voss and others 2007). In this study, an 11-point numerical rating scale (Wyn-Jones 1988) adapted from horses was used to evaluate videotapes of trotting dogs. In horses this NRS allowed detecting more subtle lameness changes than a 4- or 5-point scale (Arkell and others 2006). Lameness scoring in horses, using a numerical rating system, is reliable only when carried out by the same observer (Fuller and others 2006).

The use of videotape recordings was an efficient method for the evaluation of the dogs before and after sedation. It allowed the assessment of 105 recordings (50 dogs before and after sedation and five duplicate recordings before sedation) by four observers in a short period of time. The use of video recordings to score lameness subjectively was also reported in horses (Pleasant and others 1997). The videotapes used in the present study allowed the visualization of subtle changes in lameness by repeating the different sequences of the same dog. Additionally, it allowed a blinded assessment because the observers were not influenced by whether or not the dog had been sedated.

All observers were consistent in allocating a lameness grade to the same dog with an average difference in grade of 0.6 by a single observer, indicating low intra-observer variation. The ability to allocate a consistent score is based on experience (Arkell and others 2006). Since the sum of the differences was maximum 5 (table 3) when scoring five videos twice on a scale from 0 to 10, we can conclude that the observers were highly experienced. This is in accordance with the study about the relationship between objective and subjective assessment of limb function in dogs, which concluded that surgeons had a high correlation between first and second viewing of the same videosequence (Waxman and others 2008).

The reproducibility of the assessment between observers (inter-observer variation) was measured by comparing the given NRS score for each dog before sedation with the mean score of the four observers for that particular dog. Observer 1, 2 and 3 were reasonably consistent, their assessments varying no more than one grade from the average grade for each dog. Observer 4 graded somewhat differently, his assessment varying one or two grades from the median grade. However, like the other observers his intra-observer variation was low, as previously discussed. This illustrates the subjectivity of the NRS system and explains why this system is only valuable when subsequent scoring of one particular dog is performed by the same observer. The object in this study was to compare the global scores to evaluate a difference between two sequences and not the individual grades. Therefore the inter-observer variation in NRS scores did not affect the results or conclusions of this study. The overall agreement in global scoring between all four observers was considered moderate: $\varkappa$ = 0,45.

Although many choices of sedation exist, the two described protocols are widely used for small animals under clinical circumstances (Pawson 2008, Sinclair 2003). The dose was chosen as low as possible to avoid drowsiness and to avoid false positive results caused by the analgesic properties of α2-agonists and synthetic opiates.
The first protocol with acepromazine and methadone is used for light to moderate sedation and analgesia, but the dog was still able to walk. The dose was based on body weight but also depended on the temperament of the dog, e.g. stressed dogs

sometimes needed more sedation. In this study, three dogs needed a double dose (0.02 + 0.2 mg/kg) to allow manipulation or positioning on the table for intra-articular anaesthesia. However no different lameness grade was seen compared to dogs that received the lower dose (0.01 + 0.1 mg/kg).

The second protocol (medetomidine) is indicated when heavy sedation is needed. The dog can be positioned on the table without extensive restraint, which is ideal in small practices. As lameness evaluation was not possible in heavily sedated dogs, a fast reversal with atipamezole was needed to score lameness after sedation. The dogs were evaluated 7 minutes after atipamezole was administered. In this study, the dogs sometimes showed some residual drowsiness even after reversal with atipamezole, making lameness interpretation more difficult. Probably residual drowsiness could have been avoided by waiting a longer time after administration of atipamezole to allow complete reversal or by using a higher dose of atipamezole. In the present study 2,5 times the medetomidine dose was administered, but for this particular purpose we recommend to use a higher dose of atipamezole (5 times the medetomidine dose) as this will efficiently antagonize the sedative and behavioural effect of medetomidine within 3 to 7 minutes (Clarke and England 1989).

Overall, we observed that when lameness was affected by sedation, the difference was most frequently only one grade on a scale of 0 to 10 in both groups, which is considered minimal. In a study in horses the response to intra-articular anaesthesia was reported as 20, 40, 60, 80 or 100% amelioration of lameness, all of which were all classified as a positive response (de Grauw and others 2006). In dogs a significant change in lameness grade when intra-articular anaesthesia is performed should be at least two grades on a scale of 0 to 10, bearing in mind that sedation can reduce the lameness with one grade.

The comparison of change in lameness between two methods of sedation was not statistical significant (p-value of 0.4320). In 12% of the dogs sedated with acepromazine plus methadone and in 20% sedated with medetomidine lameness surprisingly *increased* with one grade after sedation. In three dogs (one in group ACPM and two in group MED) lameness increased by two grades on a scale of 0 to

10. This can partially be explained the distraction of the dog in an unfamiliar environment. Once sedated, dogs were more relaxed. The increase in lameness could also be explained by the induced muscle relaxation provided by sedation with α2-adrenoceptor agonists as well as with acepromazine (Sinclair 2003).

In a small number of dogs (8% in both groups), sedation did seem to decrease lameness with one grade. This could be explained by the analgesic properties of methadone and medetomidine. Although atipamezole should have counteract the induced analgesia in the MED group, some analgesia could still be present (Sinclair 2003). Again, antagonizing at a higher dose is recommended to avoid residual analgesia.

Another possibility for the change in lameness seen in both groups would be the inter-observer variation when assigning absolute lameness scores (Table 4). With experience, different clinicians tend to develop their own scoring system within the 0-10 system, some scoring higher than others. In our study one observer did score somehow different. The use of a force plate in addition to the NRS scores would have been a useful addition in this study to eliminate the inaccuracies of using a NRS scale, but was not performed because of practical considerations (time consuming, availability of the system).

Sedation with acepromazine plus methadone has the advantage that dogs can be evaluated after sedation and before intra-articular anaesthesia is performed, which enable the detection of subtle changes in lameness caused by the sedation. In the medetomidine group, dogs were not able to walk after sedation and therefore intra-articular anaesthesia could only be evaluated after antagonisation with atipamezole. For this reason, knowing that sedation can decrease lameness by one grade, intra-articular anaesthesia after sedation with medetomidine can be considered positive only when lameness has decreases by at least two grades on a scale of 10. In this study, no difference in the effect of sedation on lameness was seen between dogs with a different severity of lameness. Because of the possible decrease of lameness with one grade caused by sedation, dogs with grade 3 to 10 lameness seem to be better candidates for intra-articular anaesthesia than dogs with discrete (grade 1 to 2)

lameness. However in this study, dogs with a low average lameness grade (grade 1, 2 and 3) had an unchanged or increased lameness after sedation in both groups. The dogs with a decreased lameness were dogs with an initial higher lameness grade (4, 5 or 7).

This study illustrates that there were no important changes in lameness and no major differences between two proposed sedation protocols enabling their use prior to intra-articular anaesthesia.

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THE USE OF INTRA-ARTICULAR ANAESTHESIA AS A DIAGNOSTIC TOOL IN CANINE LAMENESS.

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SUMMARY

Lameness in dogs may be difficult to localize because of mild pathologic changes or inconclusive clinical findings. Intra-articular anaesthesia is proposed as a diagnostic method to localize the source of lameness. After a description of the preparation, technique and puncture sites, an overview is given of a series of patients admitted for different joint problems. Intra-articular anaesthesia proved to be applicable in any joint, provided that the clinician was experienced and the dog was under sedation. In 87% intra-articular anaesthesia was positive. Medial coronoid disease of the elbow joint was the most frequent indication for intra-articular anaesthesia.

INTRODUCTION

Lameness examination in the dog is based on the history, inspection and palpation of the dog and consecutive radiographs of the suspected region. In some dogs it is difficult to determine the localization of the problem because of the absence of palpable changes, or because of an unreliable pain response of the dog. In addition plain radiography cannot always be used to confirm the localization of the problem in the suspected joint because the radiographic changes may be mild or even absent. Intra-articular anaesthesia offers a simple and fast method to identify the painful joint. The joint is punctured under sedation and after retrieval of synovial fluid a local anaesthetic is injected. Consecutively the dog is observed to evaluate the effect on the lameness. Intra-articular anaesthesia can temporarily resolve lameness caused by a variety of lesions. Lameness caused by synovitis, cartilage erosions, osteochondral fragments and lesions of intra-articular ligaments can all be decreased or eliminated by performing a joint block (1).

In contrast to man and horse, diagnostic intra-articular anaesthesia has not been described in the dog. The purpose of this study was to describe the technical details, to evaluate the use under clinical conditions and to describe the indications and possibilities of intra-articular anaesthesia in the dog by analyzing a large series of patients with different joint disorders.

MATERIAL AND METHODS

During a period of four years, the files of the dogs that received an intra-articular anaesthesia were collected and analyzed. All dogs were client owned pets presented with front limb or hind limb lameness. The final diagnosis was based on the clinical and imaging findings, confirmed by arthroscopy or open surgery.

Preparation of the dog and approach to the joint was based on data from literature (1) and from own experience. An analysis of the injected joints and their final diagnose was performed to describe the effect of intra-articular anaesthesia and the indications of the technique.

Sedation of the dogs

In most dogs sedation was necessary to allow the joint puncture and subsequent injection of the local anaesthetic. Two protocols were used: acepromazine (0.01 to 0.02 mg/kg given IV) and methadone (0.1 to 0.2 mg/kg given IV), or medetomidine (dosage was calculated based on body surface area and given IV) afterwards antagonized with atipamezole given intramuscularly (2).

Positioning and preparation of the dog

The animal was placed in lateral recumbency with the affected joint uppermost, except for the elbow in which a medial approach was preferred. The puncture site was clipped and cleaned with a chlorhexidine/povidone-iodine scrub and alcohol.

Puncture sites

Based on the data from literature (3, 4) and the authors' clinical experience, joint punctures were performed according to the described techniques (text box).

Shoulder joint

The joint is placed in a neutral position and punctured craniolaterally between the acromion and the caudal part of the greater (Fig. 1). The needle is directed caudomedially and slightly downward. When entering the joint space, a slight decrease of resistance can be noticed.

Figure 1: Bony specimen and cadaver of the shoulder joint.

Elbow joint

The dog is placed in lateral recumbency with either the affected limb uppermost or on the table, according to a lateral or medial approach. Lateral injection is chosen for dogs with a deep thorax or excessive skin folds. In both ways, the needle is inserted in the intertrochlear foramen proximal and parallel to the anconeal process (Fig. 2).

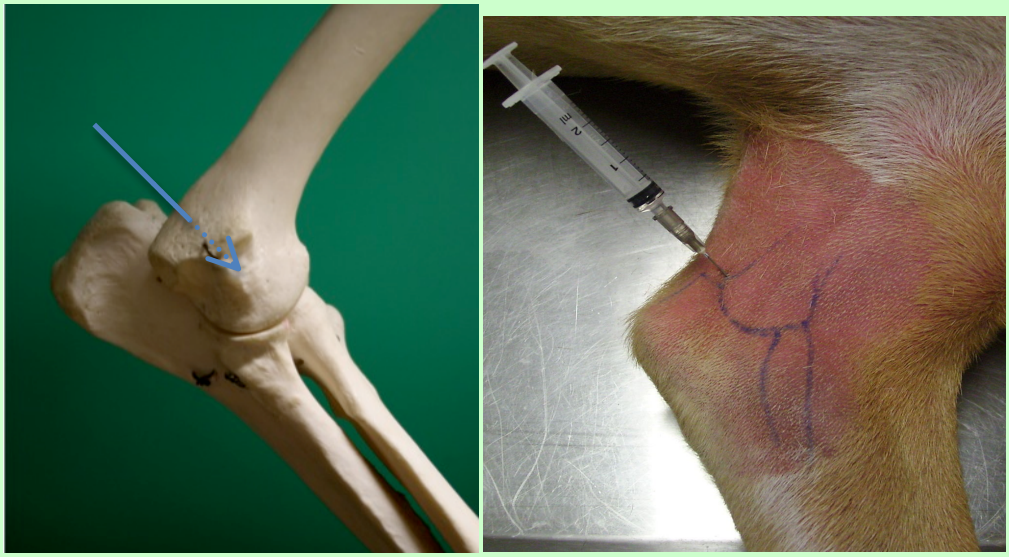

Figure 2: Bony specimen and cadaver of the elbow joint.

Carpal joint

The antebrachiocarpal joint is the most frequently punctured. The carpus is flexed to 90° (Fig. 3). A depression, corresponding to the antebrachiocarpal joint space, is palpable distal to the radius. The needle is inserted lateral or medial to the common digital extensor tendon and cephalic vein, which passes over the centre of the dorsal joint space. Injection of the intercarpal and carpometacarpal joints can be performed by flexing the carpus maximally. The intercarpal and carpometacarpal joints communicate with each other, but not with the antebrachiocarpal joint.

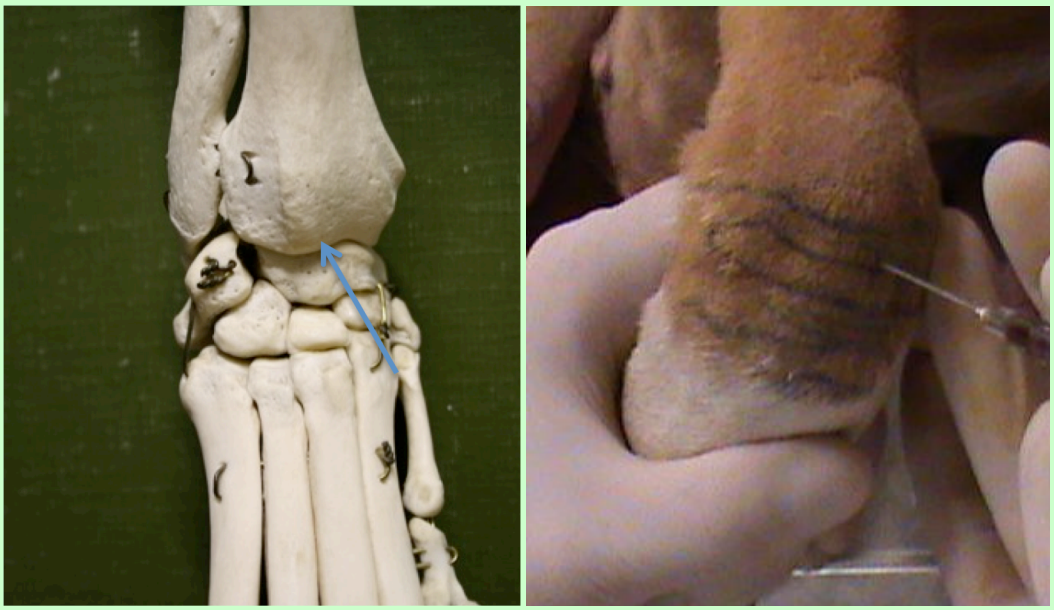

Figure 3: Bony specimen and cadaver of the carpal joint.

Hip joint

The dog is placed in lateral recumbency with the hind limb parallel to the table surface and in neutral position. The needle is inserted closely dorsal to the greater trochanter and perpendicular to the long axis of the limb (Fig. 4).

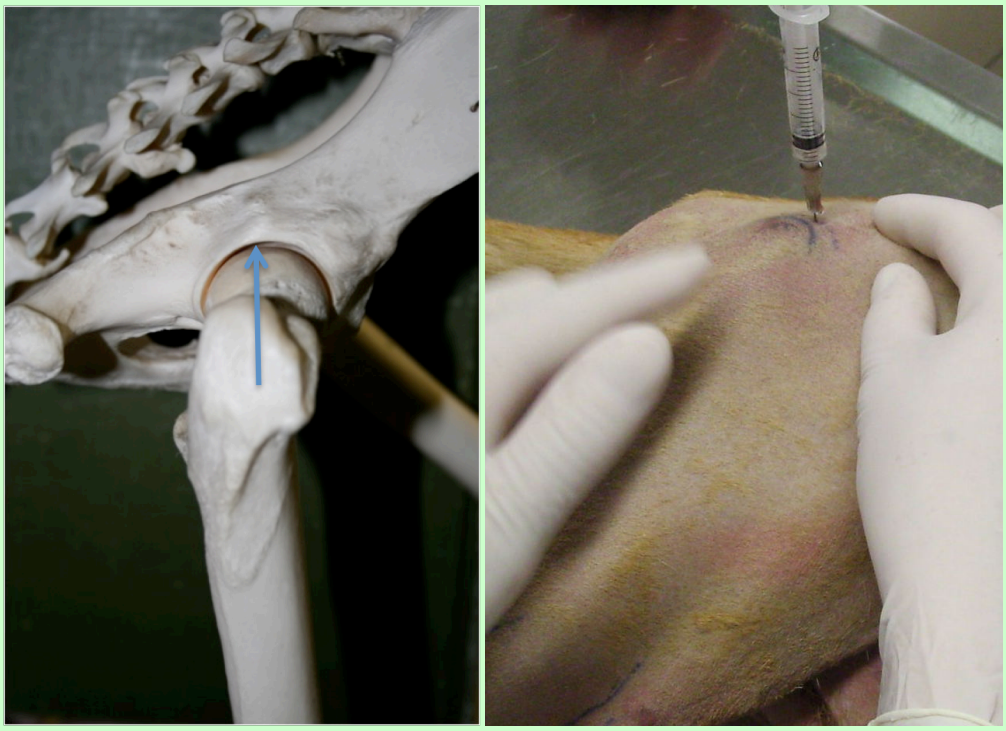

Figure 4: Bony specimen and cadaver of the hip joint.

Stifle joint

The dog is placed in lateral recumbency with the stifle flexed to 90°. The joint can be punctured lateral or medial to the straight patellar ligament. The needle is directed towards the centre of the intercondylar joint space and parallel to the tibial plateau at an angle of 45° to the skin, midway between the patella and the tibal tuberosity (Fig. 5).

Figure 5: Bony specimen and cadaver of the stifle joint.

Hock joint

The dog is positioned in lateral recumbency, with the affected limb uppermost. The joint can be punctured dorsolaterally, i.e. cranial to the ridges of the trochlea and distal to the tibia. Alternatively, the joint can be punctured plantarolaterally, between the distal part of the tibia and the calcaneus. In mildly distended cases, the joint fluid should be pushed towards the puncture side (Fig. 6)

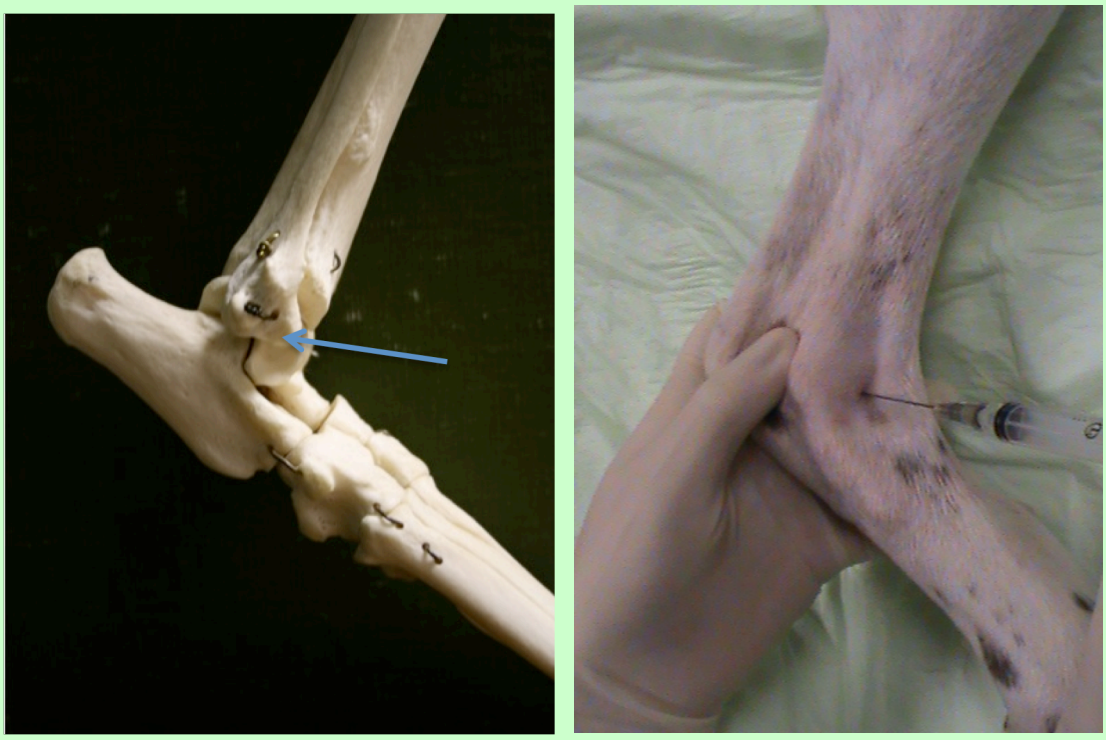

Figure 6: Bony specimen and cadaver of the hock joint.

Intra-articular injection

The clinician used sterile gloves, syringes and needles. Most commonly, a 25 mm, 22-gauge needle and a 2 ml syringe was used. A 55 to 75 mm, 22-gauge spinal needle was required for the hip joint in large or obese dogs, and a 23- or 25-gauge needle was used for distal joints and for small dogs. The needle and syringe were connected before needle insertion. Synovial fluid was retrieved before injecting the local anaesthetic into the joint. Mepivacaine (Scandicaine 2%®, 20 mg/ml, AstraZeneca, Belgium) was administered at a dosage of 1.5 mg/kg (1). To ensure a correct technique, it was required that the injection of the local anaesthetic into the joint space did not offer any resistance. If resistance was encountered, the needle should was redirected or slightly withdrawn until minimal resistance was encountered. Once the local anaesthetic was injected the joint was flexed and extended to evenly distribute the anaesthetic into the joint.

Interpretation of the effect of intra-anaesthesia

All dogs were videotaped during walking and trotting. During the first five minutes, the dog was walked continuously. If lameness did not improve during that period, walks were repeated every five minutes for a maximum of 30 minutes, until the lameness eventually improved. The effect of the intra-articular anaesthesia was evaluated by two experienced clinicians at the time of the clinical examination and at a later point in time by scoring the recorded video sequences. Lameness was graded from 0 to 10 (0/10 = sound at all times; 10/10 = continous non-weight bearing lameness; (5)). Intra-articular anaesthesia was considered positive when lameness improved by at least 2 grades on a scale of 0 to 10. The effect was considered negative if lameness did not improve 30 minutes after the intra-articular anaesthesia or as soon as one of the two observers did not see an improvement of at least two grades.

RESULTS

A total of 190 client owned dogs were included in this study. In 161 dogs front limb lameness and in 29 dogs limb lameness was observed. The number of joints, the effect of the intra-articular anaesthesia and the final diagnosis are listed in table 1. A temporarily amelioration of lameness (minimal 2 grades on a scale of 0 to 10) after intra-articular injection was noted in 166 dogs, which confirmed that the suspected joint was the localization of the problem. In 24 dogs the intra-articular anaesthesia was negative. Further diagnostic work-up using scintigraphy, CT or MRI demonstrated pathology in the injected joint of 18 dogs. Those cases are called 'false negative'. In six dogs, the cause of lameness was not in the injected joint. In those cases the result of the intra-articular anaesthesia was true negative. Results are shown in Table 1.

Joint	Total joints	Positive	Falsely negative	Negative	Diagnosis
Elbow	**131**	**110**	**15**	**6***	**All**
	111	97	14		MCD
	2	2	0		MCD+OCD
	1	1	0		OCD
	1	1	0		LPA
	5	4	1		Flexor tendon enthesopathy
	1	1	0		Incomplete ossification of the humeral condyle
	4	4	0		Infection
Shoulder	**30**	**28**	**2**	**0**	**All**
	18	18	0		OCD
	9	8	1		Partial rupture biceps tendon
	2	1	1		Calcified body
	1	1	0		Infection
Tarsus	**2**	**2**	**0**	**0**	**All**
	1	1	0		OCD
	1	1	0		Old fracture calcaneus
Stifle	**23**	**22**	**1**	**0**	**All**
	2	2	0		OCD
	8	7	1		Partial rupture cranial cruciate ligament
	6	6	0		Meniscal injury
	2	2	0		Patellar luxation
	1	1	0		Tendinosis patellar ligament
	4	4	0		Infection
Hip	**4**	**4**	**0**	**0**	**All**
	4	4	0		Hip dysplasia

Table 1. Results of 190 joints injected with intra-articular anaesthesia. P= positive result; N= negative result *panosteitis (2), n. radialis paralyse (1), tumor of the scapula (2), OCD of the shoulder (1), fractured sesamoid bone (1)

DISCUSSION

This study was conducted to evaluate the possibilities and limitations of diagnostic intra-articular anaesthesia in dogs as an alternative to scintigraphy for the localization of lameness. In men, intra-articular anaesthesia is used to specify the localization of a problem within a certain painful region (6). In horses, it is applied in a systematic way, starting distally and moving proximally until the test is positive (7, 8). In this study of dogs, the most suspected joint was punctured first, based on the history, clinical and radiographic findings. Even if those findings were not conclusive, the authors indicated the most likely joint based on their clinical experience. A systematic approach as used in the horse is not applicable in the dog: indeed, dogs need to be sedated to allow an intra-articular injection, need to be retained on a table and injection of the small canine joints is not always easy. Compared to the horse there is a lesser need for intra-articular anaesthesia of the toe and carpal joints because in the dog those joints are easy to examine clinically and radiographically and the frequency of the problems leading to lameness is rather low.

Some dogs may tolerate an intra-articular injection without sedation, but the risk of a pain or defense reaction and subsequent iatrogenic damage during the procedure is increased. Therefore sedation was used in all dogs of the study. In a previous study, two sedation protocols (acepromazine and methadone or medetomidine) were examined for use prior to intra-articular anaesthesia in the dog (2). The conclusion in that study was that there were no important changes in lameness due to sedation and no major differences between the two proposed sedation protocols. This was also experienced during the present study.

The approach of the joints and puncture sites described in this study aims to minimize iatrogenic cartilage lesions and morbidity by avoiding neurovascular bundles, tendons and ligaments. Careful handling of the needle is required to avoid iatrogenic damage and pain reactions of the sedated dog in case of the acepromazine protocol. Puncturing the small canine joints is often difficult: the joint space of the shoulder and the hip are difficult to localize because of the large muscular layer. The carpal and tarsal joint are superficial and lightly palpable but small. The elbow and stifle joint are quite easy to puncture but synovial fluid cannot always be aspirated. One of the prerequisites to have a valuable test is the correct intra-articular position and subsequent injection. Therefore intra-articular anaesthesia should be considered as an advanced technique and the clinician needs to be experienced in puncturing joints. This fact could be considered as a limitation of the technique, despite its simplicity and direct result.

A limitation of this study is the use of a visual scoring method for the evaluation of lameness instead of an objective measurement, more specifically a force plate or pressure plate (9, 10). However the use of a force plate is very time consuming (11), which is not easily applicable when a large group of patients needs to be examined during the daily clinical activities. In our study inter- and intra-observer variation were avoided by using several experienced observers, judging the animal during direct inspection and afterwards on randomised video sequences. Furthermore, the applied 11 point NRS system allowed detection of more subtle lameness changes than a typical 4- or 5-point scale (12). Moreover, the videotapes used in the different studies allowed the visualization of subtle changes in lameness by repeating the different sequences of the same dog.

Intra-articular anaesthesia confirmed the suspected joint as the localization of the problem in 166 of 190 cases (87%). In 3 % the method tested negative, meaning that the problem was not located within the injected joint. In 9 % the test was falsely negative, meaning that the problem was indeed located within the injected joint but lameness was not significantly decreased. This is one of the major limitations of the technique. Therefore negative results should always be interpreted with care and other diagnostic techniques should be used for further work up.

In this study of 190 joints intra-articular anaesthesia of 131 elbows and 30 shoulders was described. The distribution of the joint disorders in this series of patients reflects the more challenging orthopedic cases as has been described in literature. Especially forelimb lameness in dogs often leads to a clinical dilemma in terms of definitive localization and determination of the cause. It has been suggested that the most common sources of lameness that prove difficult to localize and definitively diagnose involve the elbow and/or shoulder joints (13).

Forelimb lameness associated with elbow pain is common in large breed dogs and medial coronoid disease (MCD) is the most frequent cause (14). Radiography has been used as a surveying tool for the assessment of elbow dysplasia for many years although elbow pathology is not always clear on plain radiographs (15). In the cases in which the orthopaedic examination and/or conventional radiography did not enable the clinician to localize the painful joint, intra-articular anaesthesia could be very useful. In this study 14 dogs with MCD showed a falsely negative effect of the intra-articular anaesthesia. The influence of the technique on different forms of medial coronoid disease has been evaluated in another clinical study. It was concluded that lameness caused by all types of MCD could significantly be decreased with intra-articular anesthesia, even in case of minimal lesions. However, a small percentage of the reactions is falsely negative, suggesting that a negative test does not exclude the presence of a coronoid problem.

In contrast to more distally located joints, the shoulder is more challenging for the evaluation of joint effusion and pain because of the large muscular layer. However intra-articular anaesthesia is less often needed for shoulder problems because of the clear clinical and radiographic lesions of the most common shoulder problem, which is OCD. Other shoulder disorders such as biceps problems and calcifications at the caudal rim of the glenoid cavity can be more challenging and intra-articular anaesthesia can contribute to the further workup by confirming the shoulder as the problem site. Full assessment of the shoulder joint may require other diagnostic tests and more advanced imaging methods such as ultrasound and contrast arthrography. Anaesthetic arthrography is a combination of intra-articular anaesthesia with a contrast medium and can be performed to ensure intra-articular injection and to combine diagnostic anaesthesia with another diagnostic imaging technique. In the

dog's shoulder, positive contrast arthrography enhances visualization of important intra-articular structures including the articular cartilage, the synovial membrane outline and the biceps tendon (16, 17). A recent study demonstrated that the quality of the shoulder arthrograms was unchanged and mixing contrast medium with a local anaesthetic did not interfere with the effect on lameness.

The carpus consists of three levels of joints and surrounding joint capsule and ligaments. The most common conditions are fractures of the individual bones or trauma to the collateral ligaments, which can easily be diagnosed on palpation and radiography. Diagnosing the less common mild carpal disorders may be difficult and in those cases intra-articular anaesthesia may be of help. In this study the necessity for the use of intra-articular anaesthesia in the carpus was not encountered.

In the described series, intra-articular anaesthesia for hind limb lameness was only performed in 29 of the 190 joints. In dogs with hind limb lameness, the hip and stifle joint are both commonly affected. Only four hip joints were injected with a local anaesthetic. Hip problems are easily diagnosed based on the clinical and radiographic findings. Only in case of discrete pathology or when multifocal lesions are present, intra-articular anaesthesia can be useful. The technique was more often performed in the stifle (23 / 29). Most stifle problems are caused by a ruptured cruciate ligament with or without a meniscal tear. This was also reflected in our study. Cranial cruciate ligament ruptures are characterized by instability and clear radiographic changes. Diagnosis may be difficult when a partial cruciate ligament rupture is present without palpable instability and with minimal radiographic changes. Diagnosis of meniscal tears equally can be problematic because a typical click is often absent. Also when stifle lesions are found in addition to other joint problems such as hip dysplasia, intra-articular anaesthesia can be useful. In contrast to the horse, the canine tarsal joint rarely required intra-articular anaesthesia. Not only is this joint less frequently affected with lameness problems, the localization of the tarsus is usually quite evident during the clinical examination.

Although this clinical study allowed us to draw conclusions about the possibilities and limitations of intra-articular anaesthesia in different joints, it did not focus on the

severity and type of lesions. This seemed especially interesting in the elbow joint because of the different appearances of medial coronoid lesions. Another aspect, which required further investigation, was the combination of intra-articular anaesthesia with arthrography in the shoulder. Both themes were further elaborated in detailed studies.

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DIAGNOSTIC INTRA-ARTICULAR ANAESTHESIA OF THE ELBOW IN DOGS WITH MEDIAL CORONOID DISEASE.

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SUMMARY

The objective of this study was the assessment of the effect of intra-articular anaesthesia on lameness caused by medial coronoid disease.

This study included 90 dogs that were evaluated for the complaint of unilateral forelimb lameness. All dogs were suspected of having an elbow problem for which orthopaedic examination and radiographs showed inconclusive findings. Following a short sedation, mepivacaine was injected intra-articularly to determine whether lameness was caused by a suspected elbow problem. This effect was compared with the final diagnosis based on computed tomography and arthroscopy.

Out of 90 dogs, 78 (87%) dogs had an improvement of lameness after injection of the local anaesthetic, which confirmed the elbow joint as the primary source of lameness. A positive response was seen in all types of medial coronoid lesions. A false negative result was observed in 12 dogs

Medial coronoid disease is represented by different types of pathologic lesions including chondromalacia, a fissure, fragment, and medial compartment disease. Diagnosis may be difficult because of limited clinical and/or radiographic signs. Intra-articular anaesthesia can be a helpful diagnostic tool to localize the problem by eliminating pain and reducing lameness to a great extent in all types of coronoid lesions.

INTRODUCTION

Fore limb lameness associated with elbow pain is common in large breed dogs and lesions of the medial coronoid process are the most frequent causes (1). Not only can we identify fragments of the medial coronoid process arthroscopically but also chondromalacia-like lesions, fissures, and medial compartment erosions. Therefore it has been suggested that the name medial coronoid disease (MCD) be used instead of fragmented coronoid process as a more representative term (2). Osteochondrosis dissecans (OCD) and contact lesions can be seen as concomitant lesions of the medial humeral condyle (3). Radiographic diagnosis of MCD can be challenging because the primary lesion is often not visible and even secondary signs of osteoarthritis may be minimal or absent (4). Especially in young dogs with open growth plates and also adult dogs with minimal osteoarthritis and an almost normal shaped medial coronoid process, radiographic findings may be inconclusive (Fig. 1).

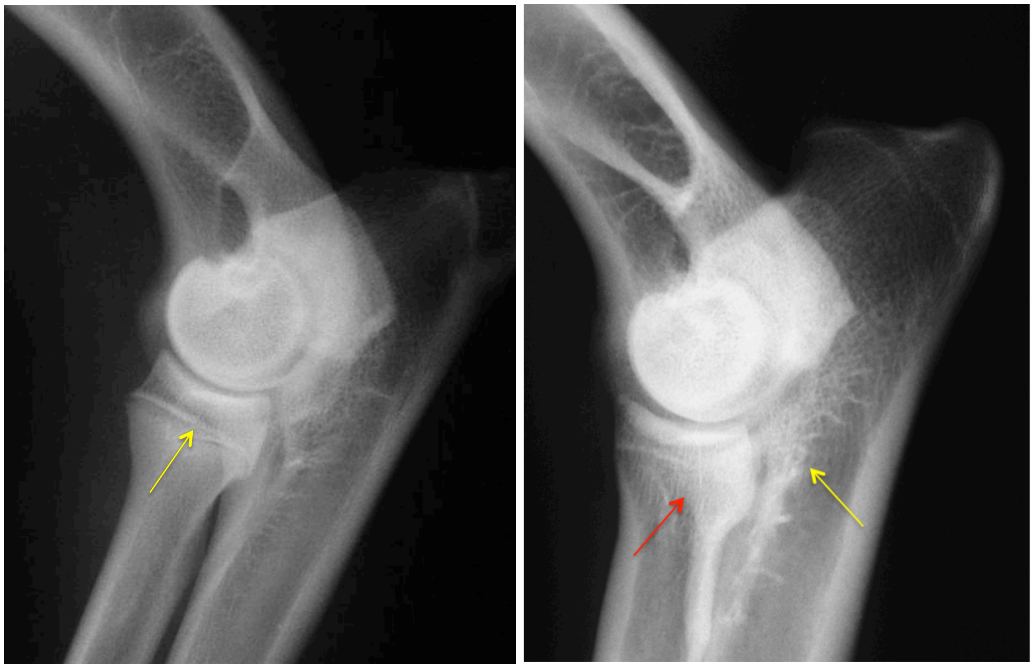

Figure 1. Examples of minimal radiographic changes in fragmented coronoid process cases. Left: young dog: coronoid process seems normal, open growth plates (yellow arrow), no arthrosis. Right: adult dog (6y) mild sclerosis (yellow arrow), unsharp delineation of medial coronoid process (red arrow), no arthrosis.

In cases where clinical changes are minimal and pain responses are not reproducible, other more sophisticated diagnostic methods are needed to establish a diagnosis. Scintigraphy can be helpful to identify the source of obscure lameness in dogs (5). This technique is sensitive but in case of multifocal uptake, no definitive diagnosis can be made. A major disadvantage of scintigraphy is the necessity to have radionucleotides and specialized staff, restricting availability of routine scintigraphy in specialized centers (6). Intra-articular anaesthesia (IA) could provide a simple, inexpensive and helpful tool to localize the painful joint because lameness in dogs is commonly associated with joint pain (7).

The use of IA as a diagnostic tool has been poorly documented in the dog (8), despite its successful use in humans and horses for many decades (9-11). When diagnostic IA is performed, local anaesthetic is injected into the suspect joint to alleviate joint pain. When pain originates from that particular joint, there should be a positive response after IA. Consequently, lameness should temporarily decrease or even resolve completely.

The purpose of this study was to establish the advantages and limitations of IA for the localization of elbow pain as the primary source of lameness in dogs and to evaluate its effect on different types of MCD.

MATERIALS AND METHODS

Animals

Candidates for this study were client-owned dogs admitted to the Faculty of Veterinary Medicine (Ghent University) with a suspicion that the dogs were suffering from MCD. All dogs were presented with the complaint of unilateral forelimb lameness without having undergoing any surgery prior to admission. Dogs were included in the study only if they had a complete clinical and radiographic examination and the final diagnosis was solely MCD, confirmed by CT or arthroscopy. All studied dogs had lameness that was a diagnostic challenge because of the present of unclear clinical signs, inconclusive radiographic signs of lesions or because of multifocal signs of pain reactions and/or lesions or some combination of these findings. Dogs were excluded from the study when the final diagnosis was not a MCD lesion.

Preparation

Prior to sedation, the dogs were videotaped during walking and trotting. Following clinical and orthopaedic examination, the dogs were sedated with a combination of acepromazine (0.01 to 0.02 mg/kg given IV) and methadone (0.1 to 0.2 mg/kg given IV), or with medetomidine (dosage was calculated based on body surface area and given IV) alone. After sedation, a radiographic examination was performed of the elbows and other joints according to the clinical findings. Based on the clinical and radiographic findings, dogs were selected for further evaluation using IA of the elbow. Dogs that had been sedated with medetomidine were administered atipamezole (dosage was calculated on body surface area and given intramuscularly) immediately after IA to reverse the effect of the sedative. The choice of medication for sedation was based on the age and temperament of the dog as well as the possibility for a surgical procedure scheduled for the same day. When dogs were scheduled for surgery on the same day as their examination, they were sedated with acepromazine and methadone whereas medetomidine was used when surgery was planned to be delayed.

Joint injection

The intra-articular injections were performed medially or laterally. The sedated dogs were positioned in lateral recumbency with the affected elbow on the table for a medial injection or with the affected elbow on top for a lateral injection. Lateral injection was chosen for dogs with a deep thorax or excessive skin folds. After clipping and aseptic preparation of the medial or lateral area of the elbow, an appropriate sized hypodermic needle was inserted in the supra-trochlear foramen, proximal and parallel to the anconeal process (Fig 2). A 25mm, 22-gauge needle with a 2 ml syringe was used for medium sized to large dogs (20-60kg) whereas a 25-gauge needle was used in small dogs (10-20kg). Following aspiration of synovial fluid, mepivacaine (Scandicaine 2%®, 20 mg/ml, AstraZeneca, Belgium) (1.5 mg/kg) was injected into the joint (Fig 3).

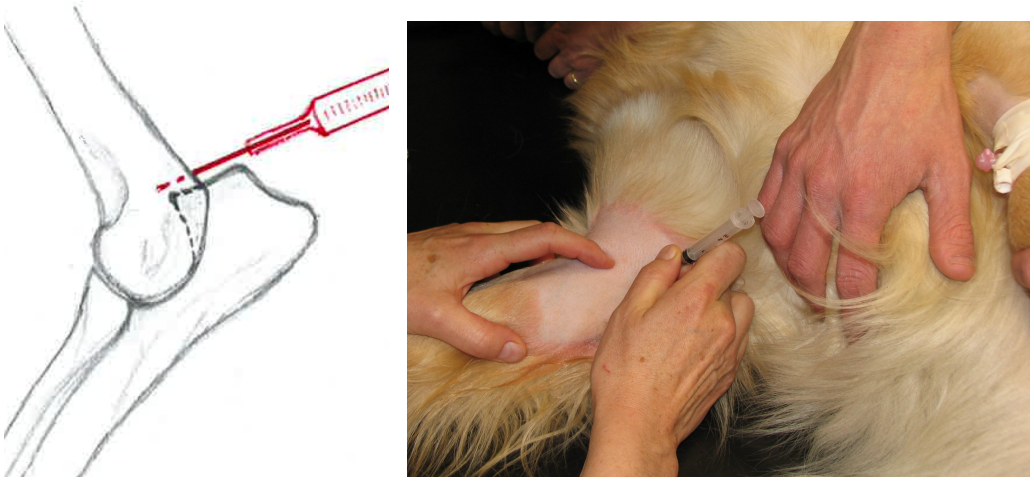

Figure 2. Injection through a medial approach: the needle is inserted lateral to the medial epicondylar ridge, parallel to the olecranon. After aspiration of synovial fluid the local anaesthetic is injected into the elbow.

Figure 3. The used local anaesthetic 'mepivacaine' for diagnostic intra-articular anaesthesia in the dog.

Effect of intra-articular anaesthesia

The effect of IA was evaluated after 2, 3, 5, 10, 15, 20, 25 and 30 minutes. During the first five minutes, the dog was walked continuously. If lameness did not improve during that period, walks were repeated every five minutes for a maximum of 30 minutes, until the lameness eventually improved. All dogs were videotaped during walking and trotting until the IA showed an effect or at 30 minutes by the latest if lameness did not improve. The effect of the IA was evaluated by two experienced clinicians at the time of the clinical examination and at a later point in time by scoring the recorded video sequences. IA was considered positive when lameness improved by at least 2 grades on a scale of 0 to 10. This 11-point numerical rating scale was developed in the UK for grading lameness in horses (12, 13). It is a subjective scoring system with 0 indicating that the dog is sound and 10 indicating a complete lack of use of a limb. The effect was considered negative if lameness did not improve 30 minutes after the IA or as soon as one of the two observers did not see an improvement of at least two grades.

To evaluate the intra-observer variance, the scores based on the video sequences were compared with the initial scores given by the two observers at the time of the clinical examination. The object was to compare the global scores (equal lameness or reduced lameness) to evaluate the difference between the sequence before and after IA and not the individual grades.

The level of agreement between scores was measured with the kappa statistic ($\varkappa$). K measures the proportion of agreement between two scores, made by different observers (14). A $\varkappa$ value between 0.21 and 0.40 was considered fair, values between 0.41 and 0.6 were moderate, values between 0.61 and 0.80 were substantial and a value of > 0.81 was considered almost perfect (15).

Diagnosis and classification of the elbow problem

Prior to the IA of the elbow, radiographs were taken of other joints according to the clinical findings. In all dogs, the elbow was the joint that was most suspected to be the source of lameness, but definitive diagnosis could not be provided based on those radiographs. Retrospectively, once the diagnose of MCD was confirmed with CT and arthroscopy radiographs were judged on the amount of osteophytosis, the presence of subtrochlear sclerosis without evidence of osteophytosis and the evaluation of an abnormal coronoid process based on its shape and delineation and the presence of a detectable fragment. All radiographs (mediolateral 90° flexed, mediolateral extended and craniocaudal) were evaluated for the degree of osteophytosis according to the International Elbow Working Group guidelines (Grade 0, no osteophytes; Grade 1, osteophytes < 2mm; Grade 2, osteophytes 2-5 mm; Grade 3, osteophytes > 5mm) (16).

All dogs underwent CT examination of the elbow joints prior to arthroscopy. CT images were obtained with a single slice helical CT[1]. Digital images were viewed on a workstation with E film viewer[2]. The subchondral bone, osteophytosis and the shape and possible fragmentation of the medial coronoid process were evaluated.

Arthroscopy was performed using a standard medial approach (17) with either a 1.9 or 2.4 mm 30° arthroscope[3]. Digital images and video recordings of the arthroscopic procedure of all the elbows were taken. Arthroscopic findings were assessed by one individual. The arthroscopic assessment included the presence or absence of synovitis, lesions of the medial coronoid process and the medial humeral condyle according to the modified Outerbridge scores (18). The assessment of the medial coronoid lesion was described as chondromalacia, fissuring or fragmentation (displaced or non displaced fragment) and medial compartment disease (erosions of medial coronoid process without clear fragmentation) (3).

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RESULTS

Dogs

Ninety dogs underwent a clinical and radiographic examination and were diagnosed with MCD based on CT and arthroscopic findings. The dogs were from different breeds (Table 1) with a mean ± SD bodyweight of 33.6 kg (± 11.3) and a mean ± SD age of 48.7 months (± 32.7). The median lameness grade was 6.5 (range 4 to 9). In total 75 dogs were older than 18 months.

Labrador Retriever Dog	20
Bernese Mountain Dog	10
Mixed Breed Dog	7
Rottweiler	6
Staffordshire Terrier	6
Boxer	5
Golden Retriever Dog	4
Dogue De Bordeaux	3
German Shepherd Dog	3
Fox Terrier	2
Bullmastiff	2
Pyrenean Shepherd Dog	2
English Bulldog	2
Argentine Dog	2
Cocker Spaniel	2
Single Breeds*	14
Total	90

Table 1. Breed distribution of 90 dogs with diagnosed MCD.

*One of each: Rhodesian Ridgeback, Flatcoated Retriever, Munsterlander, Weimaraner, Border Terrier, Nova Scotia Duck Terrier, Bouvier des Flandres, Kooiker, American Bulldog, Rough Collie, Pyrenean Mountain Dog, German Pointer, Beagle, Belgian Malinois

IA and effect on lameness

Sedation with acepromazine and methadone was sufficient to allow IA in the elbow. However, some dogs needed to be restrained on the table by two or three assistants. Pain reaction when entering the needle into the skin and joint or when intra-articular pressure increases while injecting mepivacaine was present in 5 dogs. On the other hand, sedation with medetomidine allowed painless injection and the dogs were held by only one person for safety and positioning while another person was performing the injection. No adverse reaction associated with the intra-articular administration of mepivacaine was observed. Ten dogs were injected laterally because of a deep thorax or excessive skin folds.

In 87% of the dogs, the IA resulted in a positive outcome. In those dogs, lameness improved by at least 2 degrees on a scale of 0 to 10. One dog with right fore limb lameness upon presentation showed lameness on the left fore limb as well after IA. On average, a positive effect post-injection was observed after 8 minutes. The effect was seen as early as 2 minutes but took up to 25 minutes in some dogs. The intermediate duration of action of mepivacaine allowed us to assess the effect on the lameness after a longer period of time.

In 12 dogs, a marked improvement of the lameness was not observed and such cases were indicated as false negatives. The diagnosis of MCD was made thereafter based on CT and arthroscopic findings. The inter-observer agreement was very good ($\varkappa$= 0.89) and both observers were highly consistent, giving exactly the same scores on two different occasions.

Radiographic findings and correlation with IA

The medial coronoid process was radiographically normal in 23 elbows of 90 cases in total whereas radiographic signs of an abnormal medial coronoid process was observed in the other 67 elbows. Radiographic signs of osteophytosis were present in 56 % of elbows. The osteophyte scores were 0 (54 %), 1 (24 %), 2 (17 %) and 3 (4 %) (Table 2). Sclerosis without evidence of osteophytosis was found in 32 elbows. Suspicion of contact lesions or OCD lesions was found in 24 elbows. There was no correlation between the grade of osteophytosis and the interval between injection and improvement in lameness score. Dogs with osteophyte score 2 and 3 (n=19) did always respond to the IA.

Computed tomographic and arthroscopic findings and correlation with IA

CT images gave the same final diagnosis as arthroscopy except in two cases in which CT showed a fissure and arthroscopy only chondromalacia. In these cases the final diagnosis was set as a fissure. All dogs had signs of synovitis during the arthroscopic examination ranging from mild to severe. The amount of synovitis did not correlate with the degree of pain relief after IA. The medial coronoid lesions were classified into five groups based on CT and arthroscopic findings: chondromalacia (n=10, fissure (n=41), non-displaced fragment (n=26), displaced fragments (n=7) and medial compartment disease (n=6). In the area of the medial part of the humeral condyle, contact lesions could be visualized in 30 joints and an OCD lesion in 2 joints, all concomitant with medial coronoid lesions. The responds to the IA in each of the five groups is reported in Table 2.

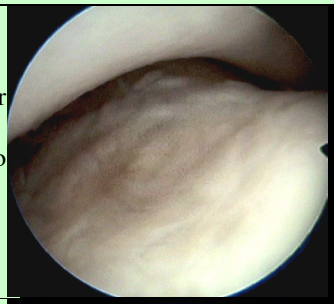
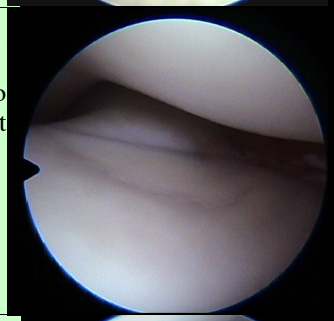
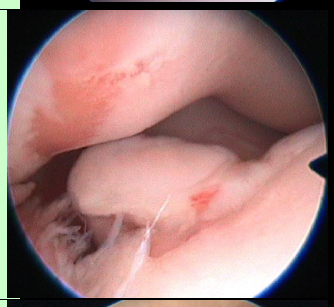
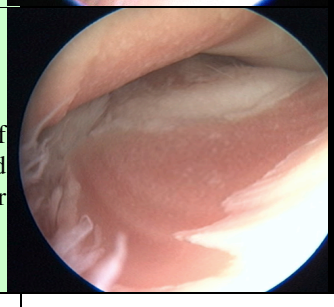
Effect intra-articular anaesthesia	Arthroscopic Diagnosis		Osteophyte scores				**Total**	Medial condyle	
			0	1	2	3		Contact lesions	OCD
Positive	Chondromalacia (Irregular, soft or fibrillated cartilage, no fissure)		0	3	3	0	6	0	0
Negative			2	2	0	0	4	0	0
Positive	Fissure (Cartilage fissure, no mobile fragment when probing)		23	7	4	0	34	6	0
Negative			6	1	0	0	7	1	0
Positive	Non Displaced Fragment (Complete fissure, fragment located at its original position and mobile when probing)		15	8	3	0	26	9	2
Negative			0	0	0	0	0	0	0
Positive	Displaced Fragment (Fragment cranially displaced)		2	1	3	0	6	8	0
Negative			1	0	0	0	1	0	0
Positive	Medial Compartment Disease (Erosions of medial coronoid process, no clear fragmentation)		0	0	2	4	6	6	0
Negative			0	0	0	0	0	0	0
TOTAL			49	22	15	4	**90**	30	2

Table 2. Distribution of arthroscopic lesions, osteophyte scores, medial condyle lesions and effect of intra-articular anaesthesia in lame dogs (n=90).

DISCUSSION

In this study, the value of IA in the elbow is described for the diagnosis of MCD causing elbow lameness. To ensure a precise diagnosis, only dogs diagnosed with MCD based on CT and arthroscopy were included. Although MCD is commonly reported as a developmental disorder affecting young dogs (19), the majority of dogs included in our study were mature (mean age of ~49 months). Also some of the breeds of dogs were atypical for MCD (Table 1). Additionally, all dogs had limited clinical and/or radiographic lesions as illustrated by the absence of effusion and pain with a low degree of osteophytosis (79% with a degree between 0 and 1). The final diagnosis based on CT and arthroscopy equally showed a distribution different from the lesions that would be expected in more typical cases. In our study the proportion of MCD lesions classified by CT and arthroscopy as fissures and chondromalacia-like lesions was higher than that reported in another (22%) study of 263 dogs with MCD (20). The higher incidence of discrete lesions such as fissures and chondromalacia-like lesions are in accordance with the discrete clinical and radiographic findings. In our study, IA was found to be very useful for the confirmation of the elbow as the primary location of the lesion.

In order to allow an intra-articular injection, the dogs needed sedation. A recent study did not find any significant effect of acepromazine and methadone or medetomidine plus atipamezole antagonisation on severity of lameness, whereby clinical evaluation of the dogs was still possible (21). As such, the authors of this study concluded that sedation does not interfere with the use of IA. The acepromazine-opioid protocol was preferred because the dogs were still able to walk before and after sedation, which allowed a direct evaluation of the IA. However, a limitation of this sedation protocol was the need for additional help to restrain the dog, which could be impractical if few co-workers are available. In such case, we propose to use the medetomidine-atipamizole combination in order to allow the evaluation of IA after reversal of the sedation (21).

Mepivacaine has been used for many years as a diagnostic anaesthetic in horses and has been shown less reactive as compared to lidocaine when injected intra-articularly

(7, 22-24). Also, a recent in vitro study showed that bupivacaine may cause chondrotoxicity (necrosis) on canine chondrocytes (25). Additionally, mepivacaine has a rapid onset of action (5 to 10 minutes) as well as an intermediate duration of action (120 to 150 minutes). Other advantages are the wide therapeutic index and limited tissue reaction (26). The dose of mepivacaine depends on the size of the dog and should not exceed the therapeutic dose of 5 mg/kg (7). In this study, a relative low dose (1.5 mg/kg) of local anaesthetic was used. The low volume injected (2 ml for a medium-size dog) was sufficient to partially eliminate pain in many dogs (78 out of 90 cases). Without exceeding the recommended dose, the low dosage permits an additional injection of another joint in case of a negative IA (7).

Prior to the injection of the anaesthetic, synovial fluid was always aspirated in order to confirm the intra-articular location of the needle. Retrieving synovial fluid may be difficult when the elbow is minimally distended or when the needle is obstructed by synovia or joint debris (27). In those cases, one can only rely on the lack of resistance during injection of the local anaesthetic or back flow after injection. A confirmation of the intra-articular position is important to avoid false negative results (7).

The dogs were most frequently injected medially which is the preferred location to perform elbow arthroscopy (28). On the other hand, dogs with a deep thorax or excessive skin folds were injected laterally. Note that both injection sites worked equally well.

Signs of pain reactions caused by the insertion of the needle or the increased intra-articular pressure while injecting mepivacaine in 6 % of the dogs that were sedated with acepromazine and methadone implies that medetomidine was more useful in reducing pain associated with IA.

In this study, an average of 8 minutes was needed before a positive effect of IA was seen. Many dogs showed an increase in lameness immediately after injection. This could be explained by the acute distention of the joint capsule which contains many pain fibers (29). An improvement was seen as soon as 2 minutes after injection but

took up to 25 minutes in some dogs. Therefore, following the injection the effect of the local anaesthesia should be allowed for a sufficient time period.

Complete analgesia defined as 100% improvement of lameness, is the ultimate goal when performing diagnostic IA. However, this was almost never achieved in this study. Almost all dogs remained visibly lame after the IA. Therefore a response can only be regarded as positive when a significant improvement defined as a change of minimally two grades on a scale of 0 to 10 is observed. With this in mind, dogs with a discrete lameness (grade 1 on a scale of 0 to 10) are not good candidates for IA.

The use of videotape recordings was an efficient clinical method for the evaluation of the dogs before and after IA. It allowed an independent assessment of the dogs by two clinicians at two different time points. Though force plate analysis is an accurate method to obtain objective data on limb loading in dogs, the veterinarian most often evaluates lameness by visual inspection because of the limited availability of a force plate (30). In this study, an 11-point numerical rating scale was used, which allowed the detection of more subtle lameness changes as compared to a 4- or 5-point scale (12, 13). In this study two of our most experienced clinicians scored the dogs on two different occasions. The ability to allocate a consistent score is based on experience (12). Since both observers gave exactly the same scores on two different occasions we can conclude that the observers were highly consistent. This consistency was mainly obtained because the object in this study was to compare the global scores (positive or negative IA) to evaluate a difference between two sequences and not the individual grades (0 to 10).

The inter-observer agreement in this study was very good as well. Only in two dogs the observers disagreed ($\varkappa$= 0.89). Both times the dogs had an amelioration of lameness of only one grade, which one observer considered as positive, while the other as negative.

IA was more effective in elbows with non-displaced fragments and medial compartment disease. The effect of IA on chondromalacia, fissures and large displaced fragments was less predictable.. False negative results in chondromalacia

and fissures could be explained by lack of penetration of the local anaesthetic into the subchondral bone because it is covered by hyaline cartilage. Articular cartilage is devoid of innervation (32) and therefore confirmed pathology may not predictably respond to IA. By contrast elbow lesions in which hyaline cartilage was interrupted or lost (non-displaced fragments, medial compartment disease, OCD and contact lesions) did have a more predictable response to the IA. The lack of response to IA in one joint with a large displaced fragment could be explained by lack of penetration of mepivacaine into the deep bone and the thickened outer layers of the joint capsule (32). Another possible explanation for false negative results is that the needle slipped out of the joint during the procedure.

In case of a false negative IA, other diagnostic methods including scintigraphy, CT, MRI and arthroscopy could be used to localize and identify the lesion.

CONCLUSION

IA of the elbow is a practical, minimally invasive tool for the diagnosis of MCD in the dog. A positive IA always indicated the exact location of the lameness; however, a negative IA did not exclude an elbow problem. The authors of this study strongly believe that IA of the elbow joint should be part of the lameness evaluation when orthopaedic examination and radiography are inconclusive.

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ANAESTHETIC ARTHROGRAPHY OF THE SHOULDER JOINT IN DOGS

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SUMMARY

The objective was to evaluate the use of intra-articular anaesthesia combined with positive contrast arthrography (collectively called “anaesthetic arthrography”) in the shoulder in order to identify and confirm the source of pain in lame dogs.

Anaesthetic arthrography was performed in 30 dogs with shoulder lameness. The effect of intra-articular anaesthesia was evaluated by an objectified visual scoring system and the arthrograms were evaluated for their diagnostic read-out.

This study showed that intra-articular anaesthesia was positive in 28 out of 30 dogs. Dilution of the contrast medium with a local anaesthetic produced an arthrogram of good quality of each shoulder. No adverse reactions were noted.

Anaesthetic arthrography of the shoulder is a simple, safe and reliable diagnostic test to confirm shoulder pain and identify a lesion. This procedure may be of particular importance in cases of occult shoulder lameness when clinical findings and plain radiographs are inconclusive.

INTRODUCTION

Disorders of the scapulohumeral joint are a common cause of forelimb lameness in dogs. A thorough history and general physical work-up as well as a comprehensive orthopedic and neurological examination are often required to identify the shoulder as the source of lameness. However, it is often difficult to localize pain in the shoulder and to distinguish it from elbow pain (1, 2). In contrast to more distally located joints, the shoulder is more challenging for the evaluation of joint effusion and pain because of the large muscular coverage. In order to localize the problem in the shoulder joint, intra-articular anaesthesia (IA) may be useful. In a study on the use of diagnostic IA of the canine elbow, it was demonstrated that this was an easy applicable and useful technique. Eighty-six percent of the dogs with an elbow lesion showed a significant improvement of lameness after injection with the local anaesthetic mepivacaine (3).

The complete assessment of the shoulder joint often requires further imaging methods such as diagnostic ultrasound, contrast arthrography, CT, magnetic resonance imaging and arthroscopy (4-6). In the dog's shoulder, positive contrast arthrography enhances visualization of important intra-articular structures including the articular cartilage, the synovial membrane outline and the biceps tendon (7, 8). Therefore, arthrography is a useful and simple technique that provides additional information for the diagnosis and treatment decision of shoulder problems.

In humans, the combination of arthrography and injection of a local anaesthetic (anaesthetic arthrography) has been described in order to confirm the intra-articular position of the contrast medium, to localize the pain source and to aid in surgical planning (9, 10). The combination of both diagnostic procedures could also be useful in canine shoulder problems.

The aim of this study was to evaluate the diagnostic effect of IA on lameness located in the shoulder and the imaging quality of the arthrogram with a combination of a local anaesthetic and a non-ionic contrast medium.

MATERIALS AND METHODS

Dogs

Over a 6 month period, all dogs with unilateral lameness and suspected of a shoulder problem were injected with a combination of a non-ionic contrast medium (Iohexolum; Omnipaque®, 240 mg I/ml, GE Healthcare, Belgium) and a local anaesthetic (mepivacaine 2%; Scandicaine®, 20 mg/ml, AstraZeneca, Belgium). In total 30 dogs had confirmed shoulder pathology and were selected for this study. All dogs included in this study were presented with front leg lameness and had a complete clinical examination and survey radiographs of both shoulders and elbows.

Preparation

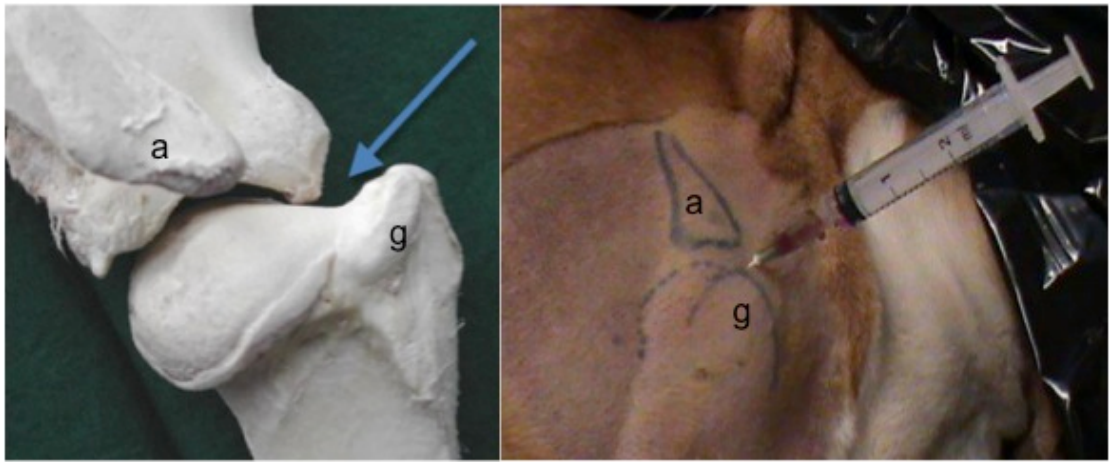
The dogs were sedated with a low dose of acepromazine (0.01 to 0.02 mg/kg) and methadone (0.1 to 0.2 mg/kg) or with medetomidine (based on body surface area) followed by antagonisation with atipamezole as described in a previous study (11). The choice between both sedation protocols was based on age and temperament of the dogs and on a potential selection for same day surgery.

Survey Radiography

Before AA was performed, survey radiographs of the shoulders were made in a mediolateral projection. The following criteria were evaluated: (i) presence of a radiolucent area or flattening on the caudal aspect of the humeral head, (ii) irregularity of the supraglenoid tubercle and osteosclerosis of the medial trochlea of the bicipital sulcus, (iii) presence of fragmentation or calcification of the caudal rim of the glenoid cavity and (iv) osteoarthritis. Radiographs of the elbows (mediolateral 90° flexed, mediolateral extended and craniocaudal) were evaluated to detect any elbow pathology.

Anaesthetic arthrography (AA)

Positive-contrast arthrograms were performed using 3 to 6 ml of a solution of Iohexolum and mepivacaine 2%, at a 1:1 ratio (100 à 120 mg I per ml). The dogs were positioned in lateral recumbency with the affected shoulder upwards and fixed in a neutral position. After clipping and aseptic preparation with chlorhexidine scrub and alcohol, the joint was punctured craniolaterally between the acromion and the caudal part of the greater tubercle in a caudomedial direction (Fig. 1a and 1b). A 25mm, 22-gauge needle with a 5 ml syringe was used for medium sized to large dogs (15-60 kg) whereas small dogs (5-15kg) were punctured with a 25-gauge needle with a 2 ml syringe. Synovial fluid was aspirated and a direct smear was made for cytological analysis. Synovial smears were judged to be inflammatory or non-inflammatory on the basis of number and types of cells.



A B

Figure 1: bony specimen (A) and cadaver (B): Lateral aspect of a right shoulder - craniolateral puncture site. The needle is inserted between the acromion (a) and the greater tubercle (g) in a caudomedial direction.

After aspiration of synovial fluid the contrast medium combined with mepivacaine was injected into the joint. After withdrawal of the needle, the injected joint was flexed and extended to allow the contrast to spread in the joint. A mediolateral radiographic projection was taken shortly after injection. The dog was stimulated to walk as soon as possible. If the dog was given medetomidine, antagonization with atipamezole was performed.

The following radiographic criteria were evaluated by one individual on arthrography: (i) presence of a cartilage flap on the caudal aspect of the humeral head, (ii) thickened articular cartilage over the defect, (iii) joint mice, (iv) decreased or irregular filling of the bicipital tendon sheath, (v) fragmentation of the caudal rim of the glenoid cavity and (vi) joint distention.

Ultrasonography

Ultrasonography[a] was performed for the evaluation of the biceps tendon and its attachment. This was performed by different clinicians with different experience.

[a] MyLab 30, Esaote, Firenze, Italy

IA evaluation

The effect of IA was evaluated after 2, 3, 5, 10, 15, 20, 25 and 30 minutes by two experienced clinicians. The dog was kept walking continuously and was videotaped before IA and when the end result was reached for later independent evaluation. IA was noted as positive when lameness improved with at least 2 grades on a scale of 0 to 10 (numerical rating scale: 0/10 sound at all times; 10/10 continuous non-weight bearing lameness) (12) compared with the lameness grade before IA. When lameness had not improved after 30 minutes, the IA was considered negative.

Arthroscopy

All dogs had arthroscopy on the same day or within a week after the AA. Shoulder arthroscopy was performed in a standardized manner for all dogs using a craniolateral approach (2.7 mm, 30° fore-oblique arthroscope for medium to large dogs and 1.9 mm or 2.4 mm arthroscope for small dogs)[b] (13). The joint was explored using a standard compartmental lateral approach. At the time of arthroscopy, fixed digital and video images of each structure were obtained for subsequent evaluation and data recording. Arthroscopic findings were assessed by one individual. Findings included: (i) presence or absence of synovitis, (ii) cartilage lesions, (iii) flaps and joint mice, (iv) partial or complete rupture of the bicipital tendon and (v) fragmentation of the caudal glenoid cavity. In doubtful cases a probe was used to assess the biceps tendon and cartilage.

[b] Richard Wolf, Knittlingen, Germany

RESULTS

Patients

Thirty dogs were successfully injected in the shoulder with the combination of mepivacaine and iohexolum. All except one were medium to large breed dogs including the Bernese Mountain dog (n=5), Border Collie (n=4), Belgian Malinois (n=3), mixed breed (n=3), Golden Retriever (n=2), Cane Corso (n=2), and one Great Dane, Barzoi, German Shepherd, Epagneul Breton, Rottweiler, Beauceron, Hovawart, German Wirehound, English Springer Spaniel, and Pyrenean Mountain dog. The small dog was an 8 kg Pug. The ages ranged from 7 months to 9.4 years (mean ± SD: 38.3 ± 36) and weight from 8 to 76 kg (mean ± SD: 31.6 ± 13.3). The degree of lameness upon presentation varied from 4 to 8 on a scale of 10 (mean ± SD: 6.33 ± 1.19) with 0 indicating that the dog is sound and 10 indicating the complete lack of use of the limb (11, 12).

Radiographs

In table 1 the results of the plain radiographs of the shoulder are described. Shoulder radiographs showed flattening of the humeral head in 16 out of 18 cases (Fig. 2), clear irregularity of the supraglenoid tubercle and/or osteosclerosis at the medial trochlea of the bicipital sulcus in 7 out of 9 cases, fragmentation or calcification of the caudal rim of the glenoid cavity in 3 cases and osteoarthritis in 7 cases.

In 5 dogs elbow radiographs were considered abnormal (Table 1). In 3 dogs an abnormal shape of the medial coronoid process was found. In one dog (case 29; Fig. 3) this was diagnosed as a fissure on arthroscopy. In one dog moderate incongruity and in one dog sclerosis was visible on the radiographs.

Case	effect of IA	Radiography		Arthrography	Ultrasonography biceps tendon	Arthroscopy
		shoulder	elbow			
1	P	Flattening humeral head	Abnormal shape coronoid process, panosteitis	Flap	Normal	OCD
2	P	OA, elongation caudal glenoid	Normal	Decreased or irregular filling of the biceps tendon sheath, fragment caudal glenoid looks isolated	Normal	Partial biceps rupture, Fragment not isolated
3	P	Flattening humeral head	Normal	Contrast line indicating a flap	Normal	OCD
4	N	Irregular tuberculum supraglenoidale	Normal	Decreased or irregular filling of the biceps tendon sheath	Thick, heterogeneous with anechoic core lesion	Partial biceps rupture
5	P	Flattening humeral head	Normal	Flap	Normal	OCD
6	P	OA, irregular tuberculum supraglenoidale, sclerosis at the medial trochlea of the bicipital sulcus	Normal	Decreased or irregular filling of the biceps tendon sheath	Thick, heterogeneous with loss of fiber	Partial biceps
7	P	Flattening humeral head	Normal	Flap	Normal	OCD
8	P	Minimal sclerosis at the medial trochlea of the bicipital sulcus	Normal	Normal	Normal	Partial biceps
9	P	OA	Normal	Irregular contrast outline	Normal	Infection
10	P	Flattening humeral head	Abnormal shape coronoid process, minimal osteoartritis	Flap	Normal	OCD
11	N	Fragment caudal glenoid, OA	Sclerosis	Two fragments of the caudal glenoid look isolated	Normal	Calcification caudal glenoid
12	P	Flattening humeral head	Normal	Flap	Normal	OCD
13	P	Flattening humeral head	Incongruent	Flap	Normal	OCD
14	P	Flattening humeral head	Normal	Flap	Normal	OCD
15	P	Flattening humeral head	Normal	Flap	Normal	OCD
16	P	Flattening humeral head	Normal	Flap	Normal	OCD
17	P	Flattening humeral head	Normal	Flap	Normal	OCD
18	P	Sclerosis at the medial trochlea of	Normal	Decreased or irregular filling of the	Loss of normal fiber, anechoic,	Partial rupture

		the bicipital sulcus, irregular tuberculum supraglenoidale		biceps tendon sheath	irregular attachment	
19	P	OA, flattening humeral head	Normal	Flap	Normal	OCD
20	P	Small indentation at caudal aspect humeral head, minimal OA	Normal	Thickening of contrast line/ no flap or subchondral defect detected	Normal	Small OCD
21	P	Flattening humeral head	Normal	Flap	Normal	OCD
22	P	Fragment caudal glenoid	Normal	Decreased or irregular filling of the biceps tendon sheath, fragment looks not isolated	Normal	Calcification caudal glenoid
23	P	OA, sclerosis at the medial trochlea of the bicipital sulcus, irregular tuberculum supraglenoidale	Normal	Decreased or irregular filling of the biceps tendon sheath	Loss of normal fiber, anechoic, irregular attachment	Partial rupture
24	P	Flattening humeral head	Normal	Flap	Normal	OCD
25	P	Sclerosis at the medial trochlea of the bicipital sulcus	Normal	Decreased or irregular filling of the biceps tendon sheath	Loss of fibers at the level of the supraglenoid tubercle	Partial rupture
26	P	Large radio-lucent area humeral head	Normal	Thickened cartilage layer, no flap	Normal	Large OCD
27	P	Sclerosis at the medial trochlea of the bicipital sulcus, osteoartritis	Normal	Complete filling of the proximal part of the tendon sheath	Loss of fiber at the level of the supraglenoid tubercle	Partial rupture
28	P	Inhomogenous subchondral bone	Normal	Flap	Normal	OCD
29	P	Minimal irregularity of the supraglenoid tuberosity	Incongruent, sclerosis, abnormal shape coronoid process	Minimal decreased or irregular filling of the biceps tendon sheath	Normal	Shoulder: Partial rupture Elbow: MCD (fissure)
30	P	Osteoartritis, Mineralization in caudal poach	Normal	Filling defect in caudal poach	Normal	Old OCD, joint mice

Table 1 – Data of 30 patients with a shoulder disorder. OA = osteoartritis; IA = intra-articular anaesthesia; P = positive; N = negative

Intra-articular injection

Both sedation protocols were sufficient to allow intra-articular injection in the shoulder. Pain reaction when entering the needle into the skin and joint was noted in 4% of the dogs being sedated with acepromazine/methadone whereas none experienced pain when sedated with medetomidine. No adverse reactions were observed associated with the intra-articular administration of the combined products.

In 28 out of 30 dogs, the intra-articular injection had a positive effect (Table 1), meaning that lameness improved with a minimum of 2 degrees on a scale of 0 to 10. The mean time ± SD before a clear positive effect was seen was 11 ± 3.51 minutes. The earliest effect was seen after 2 minutes with the last effect being observed after 15 minutes. In two dogs, no clear improvement of the lameness was observed. Those dogs were considered as false negatives because clear lesions were seen during shoulder arthroscopy with significant pathology of other joints being excluded.

The response on IA was positive in 18 out of 18 dogs with an OCD lesion. The mean time before lameness decreased was 10.39 minutes.

IA was positive in 8 out of 9 dogs with a partial rupture of the biceps brachii tendon. In two dogs, the arthrogram showed only minor changes but the IA confirmed the shoulder as being the painful joint. The mean time after which lameness decreased was 10.78 minutes. After IA, flexion of the shoulder, which is particularly painful in this condition, was less painful in all dogs. The one dog with a false negative result (case 4) was a 5-year-old golden retriever with confirmed pathology on arthrogram and ultrasound and no significant pathology in the elbow. The biceps tendon was almost completely ruptured on arthroscopy and after tenodesis of the remnants lameness resolved within one month.

One of the two dogs with a calcification of the caudal rim of the glenoid cavity showed no positive response to the IA although clinical improvement was seen after arthroscopic removal of the fragment.

The dog with the shoulder infection showed an improvement of lameness within 15 minutes after IA.

Arthrogram

All arthrograms were of good diagnostic quality (good filling of the joint and good opacity) but not all arthrograms provided a definitive diagnosis (Table 1). Osteochondrosis dissecans (OCD) was diagnosed in 16 dogs by visualization of a loose cartilage flap (Fig. 2). In two dogs (case 20 and 26) only a thickened cartilage layer on the caudal aspect of the humeral head was detected. Biceps brachii tendon pathology was diagnosed in 7 dogs but was missed in two dogs (cases 8 and 29). A calcification at the caudal rim of the glenoid cavity was seen in 3 dogs (cases 2, 11 and 22; Fig. 4 and 5). Synovial fluid was collected from all dogs. In one dog there was evidence of septic joint inflammation (>50000 wbc/ml), although no bacteria were cultured.

Ultrasonography

Ultrasound confirmed the partial rupture of the biceps brachii tendon in 6 dogs but failed to demonstrate this lesion in three other dogs (cases 2, 8 and 29). Consecutive arthroscopy confirmed the existing pathology in those cases. In the other joints, ultrasound and arthroscopy demonstrated a sound tendon.

Arthroscopy

All dogs underwent arthroscopy in order to confirm and treat the lesions. Eighteen dogs with OCD were treated by removal of the OCD flap. Tenotomy was performed in all 9 dogs with a partial biceps tendon rupture. In 2 out of the 3 dogs with a calcification of the caudal glenoid cavity arthroscopic treatment was performed by fragment removal. The fragment of the third dog (case 2; Fig. 4) was found unseparated from the glenoid cavity and therefore left untreated. In the same joint, a partial biceps rupture was diagnosed which was treated successfully with a tenotomy. The dog with the suspected infection had no underlying primary lesions and was treated by flushing followed by four weeks of a broad-spectrum antibiotic. Synovitis was diagnosed visually in all joints ranging from mild to severe.

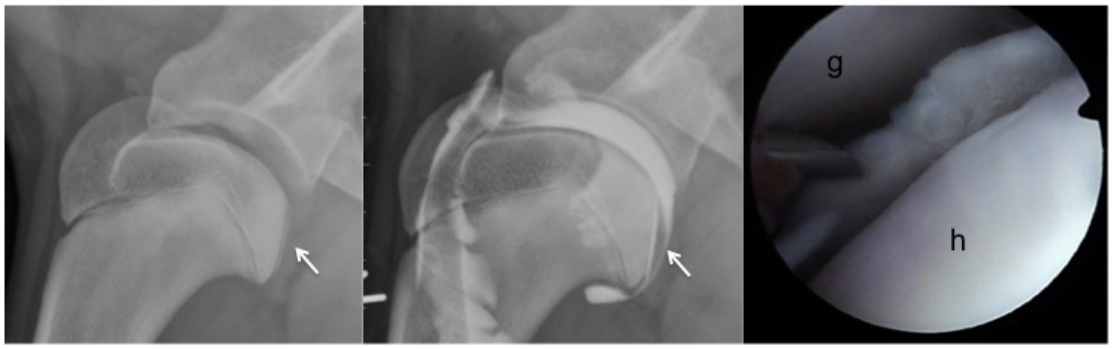


Figure 2: A. Mediolateral radiograph of case 10 (7 month old Cane corso) with osteochondrosis visible as a large defect of the humeral head (arrow). B. Arthrography with infiltration of contrast medium underneath the cartilage (arrow). C. Arthroscopic image of the same shoulder showing a cartilage flap (g: caudal glenoid, h: humeral head).

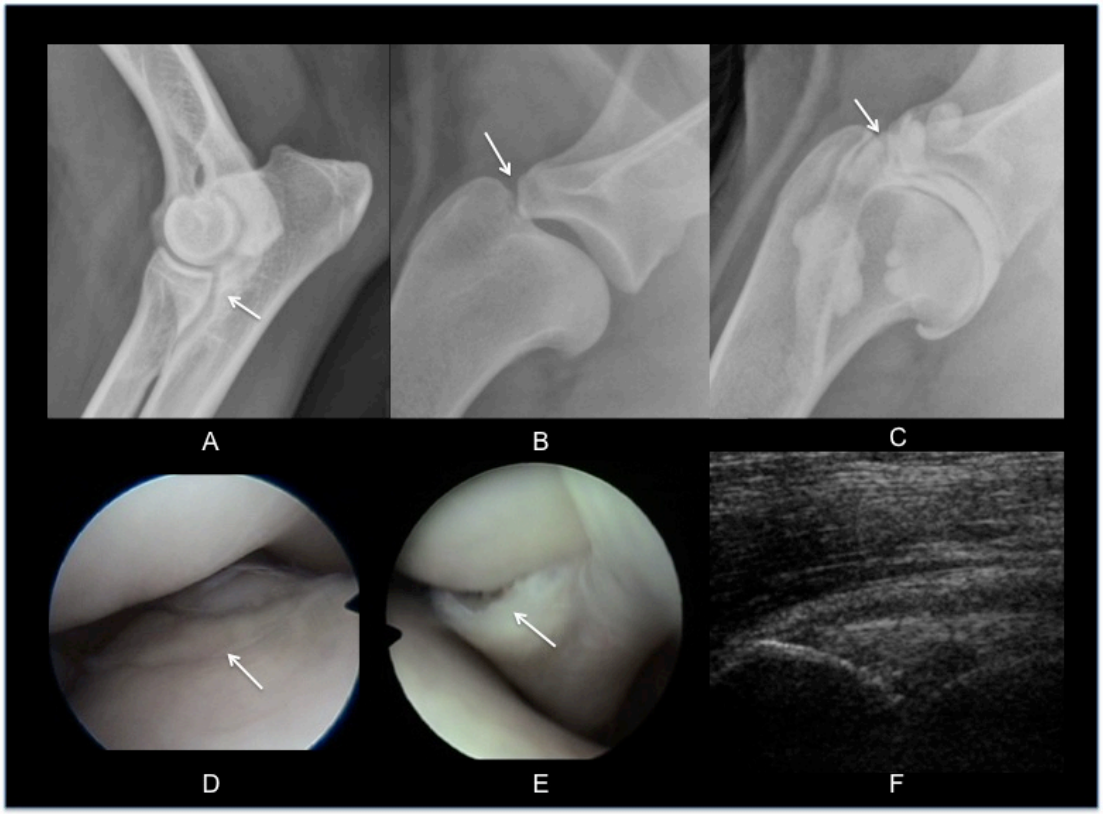


Figure 3. Images of a 2 year old Bernese Mountaindog (case number 29). A: Mediolateral radiograph of the elbow - discrete signs of sclerosis (arrow) and an abnormal shape of the coronoid process. B. Mediolateral radiograph of the shoulder of the same dog - minimal irregularity of the supraglenoid tubercle (arrow). C. Arthrography of the same shoulder - irregular outline of the biceps tendon (arrow). D. Arthroscopic image of the elbow - fissure of the medial coronoid process (arrow). E. Arthroscopic image of the shoulder - partial rupture of the biceps tendon at its attachment (arrow). F. Ultrasonography of the biceps tendon - no clear abnormalities at the attachment of the tendon.

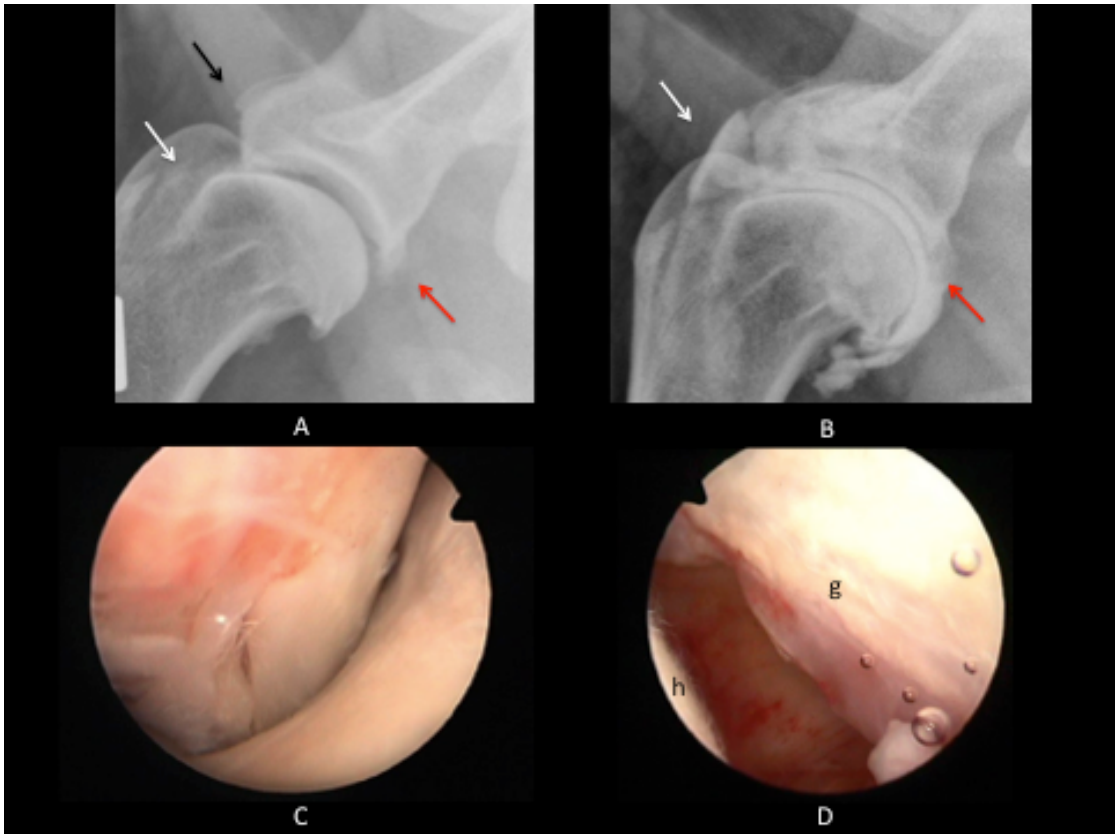


Fig. 4: Images of a 8 year old Belgian malinois with a partial biceps rupture (case 2). A. Mediolateral radiograph - osteosclerosis (white arrow) of the bicipital sulcus, periosteal reaction of the supraglenoidal tubercle (black arrow) and osteoarthritis. The glenoid cavity is elongated and may suggest the presence of a calcified body (red arrow). B. Arthrogram - unclear delineation of the biceps tendon and its sheath (white arrow). The calcified body at the caudal rim of the glenoidal cavity seems to be surrounded by the contrast medium (red arrow) C. Arthroscopic image - partial rupture of the biceps tendon D. Arthroscopic image showing the calcification at the caudal rim of the caudal glenoidal cavity (g) which is not visible as a separated fragment. A small part of the fibrillated cartilage of the humeral head (h) is visible.

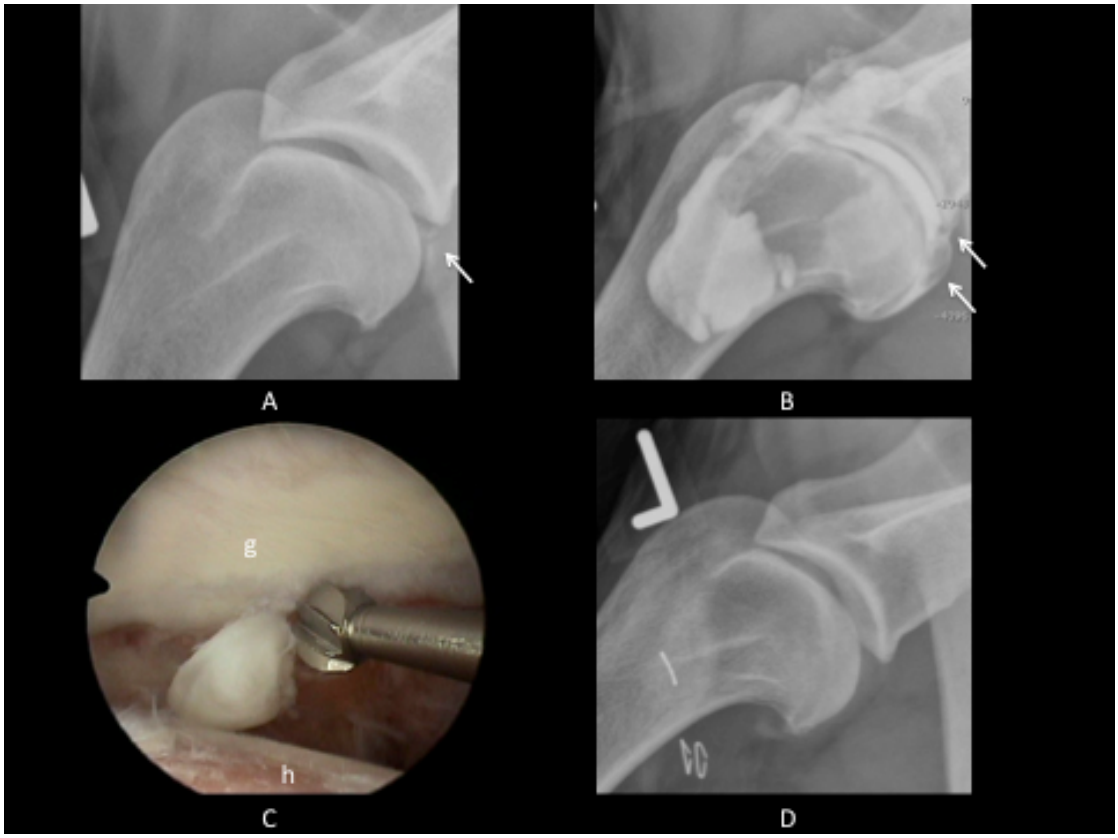


Fig. 5: Images of a 5 year old mixed breed dog (case 11) with a calcification at the caudal rim of the glenoid cavity. A. Mediolateral radiograph - large calcification with small separate fragment (arrow) B. Arthrogram - The contrast is surrounding two bony fragments (arrows), which are impinging the cartilage of the humeral head. The cartilage appears to be thinner at that location. C. Arthroscopic image - tjhe small fragment of the caudal glenoid cavity (g) which is loosened using a 2mm handburr. The humeral head shows local erosions corresponding to the arthrographic finding (h). D. Mediolateral radiograph after removal of the calcifications.

DISCUSSION

In general, clinical and radiographic examination is often sufficient to localize lameness in dogs. However, full assessment of the shoulder joint may require other diagnostic tests and more advanced imaging methods such as ultrasound, contrast arthrography, CT, magnetic resonance imaging or arthroscopy. Arthrography of the shoulder in the dog is a well-described technique although barely used in clinical practice. In addition, the combination with IA has not been reported to our knowledge. Therefore, this study of dogs with shoulder problems was initiated to investigate the value of the combination of intra-articular anesthesia with arthrography, described in human medicine as anaesthetic arthrography. The dogs included in this study were mostly medium to large sized dogs except for one Pug (8kg) and one small mixed breed (13kg). The final diagnosis of shoulder abnormalities in this study cohort was based on clinical and imaging findings and further confirmed by arthroscopy. OCD was the most frequent diagnosis followed by a biceps rupture and a calcification at the caudal rim of the glenoid cavity. In contrast to what has been reported in the literature, shoulder instability was not seen in this study (14).

All dogs needed sedation in order to allow an intra-articular injection. A recent study of the effect of sedation on lameness prior to IA showed that no significant effect on lameness was observed after sedation with two different protocols and that further clinical evaluation was possible (11). The acepromazine-opioid- protocol was shown to be the preferred sedation method because the dogs were able to walk before and after sedation, which allowed a direct evaluation of the IA. One limitation of this sedation protocol was the need for additional assistance to restrain the dog. In smaller practices, this could be a limiting factor with fewer co-workers. In such case, the medetomidine-atipamizole protocol provides an alternative by allowing the evaluation of IA after antagonisation (11).

Different sites for aspiration of the shoulder have been documented (15). The site mentioned in our study is also described as the first puncture site for shoulder arthroscopy (16). Alternatively, the shoulder may be punctured distal to the acromion.

In either case, the needle should be inserted gently and correctly to prevent iatrogenic cartilage damage. Hitting the subchondral bone may cause a substantial defense reaction. This reaction was only encountered once in this study. The volume, color and viscosity of the collected synovial fluid was helpful in identifying an affected shoulder joint.

In this study, mepivacaine was used as local anaesthetic due to its favorable properties (17). In order to perform an anaesthetic arthrogram, the contrast medium was mixed with mepivacaine. The contrast medium used in this study was a low osmolar non-ionic monomeric agent, which causes minimal synovial inflammation and a slow resorption (18). The volume and concentration of Iohexolum was based on contrast studies in average-sized canine shoulders (19). To prevent the arthrogram from being too radiopaque, a dilution of the contrast to 100 à 120 mg I per ml is required. Since most contrast products have a concentration of 200 to 300 mg I per ml, a 1: 1 combination with mepivacaine provided the ideal dilution and volume. No adverse reactions to the intra-articular injection of the combined products were observed except for minor pain reactions in 4 % of the dogs, which were caused by the insertion of the needle or the increased intra-articular pressure while injecting the product.

According to the literature (8, 20), arthrography of the shoulder joint is a valuable diagnostic method in dogs with obscure lameness when plain radiographs are negative or inconclusive. This technique was found to be accurate in evaluating the status of the articular cartilage and more importantly, it is particularly useful for separating surgical from nonsurgical candidates in case of bilateral OCD (21). All arthrograms obtained in this study were of good diagnostic quality and gave more information than the plain radiographs (Table 1), which indicates that dilution with mepivacaine does not interfere with the image quality.

Ultrasonography showed to be useful for the evaluation of the biceps tendon. In three dogs (cases 2, 8 and 29), ultrasound did not demonstrate the partial rupture of the biceps tendon. In those dogs, the AA had a positive effect and confirmed the presence of pathology within the shoulder. Some care should be taken to interpret these findings because observers with a different level of experience performed the

examination. In addition, ultrasound was performed after the AA, which caused some minor accumulation of fluid and air bubbles with minimal disturbance of the evaluation of the biceps tendon. Ultrasound prior to AA, however, might improve the diagnosis of biceps lesions.

Diagnosis of shoulder OCD based on clinical and radiographic examination is usually straightforward. However, when manipulation of the shoulder does not elucidate a pain reaction or when radiographic findings are subtle (cases 20 and 28), the exact diagnosis may be difficult to obtain. In those cases, AA may prove to be helpful for further confirmation of the location of lameness and the identification of the lesion. In this study, two cases showed minimal clinical and radiographic changes. AA led to a decreased lameness and demonstrated a small defect in one joint and a large flap in the other joint.

The benefit of plain radiographs of the shoulder joint in cases of bicipital lesions is low because the radiographic changes are not very specific. Osteosclerosis of the intertubercular groove has been described as a radiographic feature of bicipital injuries (22). In addition, a periosteal reaction and osteosclerosis of the supraglenoid tubercle can often be demonstrated. In the described cases, 7 dogs showed a relatively apparent osteosclerosis and/or an irregular supraglenoid tubercle. In two dogs the radiographic changes were not clear (cases 2 and 8). Confirmation with ultrasound, arthrography and arthroscopy is desired if tenodesis is considered as a possible treatment. Positive contrast arthrography has been described as an additional imaging tool (23) and was found to be more sensitive compared to ultrasonography for the diagnosis of biceps lesions (24). In this series arthrography added additional information for the diagnosis of a biceps lesion except in one dog (case 8). Arthrography was more helpful then ultrasound in two dogs (case 2 and 29). Finally, direct visualization of the biceps tendon via shoulder arthroscopy is recognized as superior to the other diagnostic procedures (25). Arthroscopy could demonstrate clear biceps lesions in all 9 cases even when the arthrogram or ultrasound did not show obvious lesions. With AA however, the shoulder was confirmed as the localization of the problem which justified arthroscopy of that joint.

Calcified bodies at the caudal rim of the glenoid cavity are a rare cause of lameness in the canine shoulder. Often, this observation is classified as a clinically insignificant lesion even though it has been described as a possible cause of shoulder lameness (26). Since the calcified bodies are not always the cause of lameness, diagnosis should be based on the localization of pain in the shoulder and the exclusion of other shoulder and front limb problems. In this study, three dogs had a fragmentation of the glenoid cavity (cases 2, 11 and 22). In two dogs (case 2 and 22), AA confirmed the shoulder as the painful joint but arthrography showed no other pathology in one dog and complimentary biceps pathology in the other joint. In the latter dog (case 22), arthroscopy demonstrated that the calcification was a bony elongation of the glenoid, suggesting that it was of no clinical importance. Treatment was therefore limited to the ruptured biceps tendon, which could be considered as the primary cause of lameness since arthroscopic transection resolved lameness. In one dog (case 11), IA was negative and arthrography showed no other shoulder pathology besides a calcified body at the caudal glenoid cavity. In addition, there was mild osteosclerosis of the ulnar trochlea notch of the elbow. In the latter case, diagnosis was only definitive when arthroscopy enabled the visualization of the calcified body. In absence of other shoulder pathology, this fragmented part of the glenoid cavity is considered as the primary cause of lameness, which was confirmed by the positive outcome after arthroscopic removal. However, occult elbow lesions may be present and should be ruled out as the cause of lameness as well. In this case, only shoulder pain could be elucidated and synovial fluid of the shoulder was abnormal, which led us to the shoulder. In this particular case, AA failed to reduce lameness, which reminds us of its limitations. In this study 4 other dogs had radiographic changes on the elbow. In all of these cases AA of the shoulder was positive which did confirm the shoulder as the cause of lameness and the elbow lesions being clinically irrelevant.

This study demonstrates that AA or the combination of intra-articular anaesthesia with arthrography is a fast, noninvasive and very efficient diagnostic tool to localize shoulder problems and provide additional diagnostic information with only one intervention. This diagnostic technique may be helpful when abnormalities are detected simultaneously in the shoulder and/or other joints - often the elbow (2)- or when plain radiographs do not confirm suspected pathology of the shoulder. However, both IA and arthrography have their limitations and may provide eventually

false negative results. In those cases, further diagnostic methods including CT, MRI, scintigraphy or direct arthroscopic visualization should lead to the final diagnosis.

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GENERAL DISCUSSION

Lameness is one of the more common problems encountered in veterinary practice. The gait is disturbed, which is in most cases in response to pain and only rarely due to a mechanical or neurological problem. It is generally accepted that an early diagnosis and surgical treatment are helpful in slowing down the progression of the disease and subsequent eventual osteoarthritis (1).

An early or correct diagnosis starts with the determination of the location and the cause of lameness which can be very challenging, even for the experienced veterinarian. In dogs a thorough physical orthopedic examination will often indicate the site of lameness. The orthopedic examination includes the history and the detection of palpable changes, eventually confirmed by a pain reaction. Joint distension and a reduced range of motion often indicate the site of the problem, but the findings may be subclinical and not related to the lameness. In other cases, the palpable signs may be minimal or absent, even in cases of severe lameness. Therefore, confirmation of the localization of the problem is necessary.

Since a dog cannot indicate the painful site, several helpful applications need to be applied to localize the source of the problem. The simplest way is to elicit pain by hyperflexion and hyperextension of the joint or by applying pressure on the painful spot. In many cases, this will provoke a pain response, suggesting that the problem site was probed. However, in some cases the pain response is unreliable due to high pain tolerance, stress or aggression of the dog. A helpful test could be the flexion test, described in horses since 1923 but which is not known as a routine diagnostic test in dogs (2). In a flexion test a joint is held in hyperflexion for a short period of time (30 seconds to 2 minutes) and then the horse is immediately observed for increased lameness. If a particular flexion test intensifies the lameness, the veterinarian can concentrate on that joint as the possible source of the lameness during the further course of the examination. This test has been used successfully in our clinic to locate obscure lameness in dogs. Although it can be very helpful, false negative tests can occur. Furthermore, it is described that some normal horses, clinically and radiographically, can have a positive flexion test. For this reason, the response to flexion must be interpreted in the light of clinical and radiographic findings (2). Additionally, dogs do not always allow a flexion test. Alternatively, scintigraphy can

be used to identify the localization of lameness in dogs (3, 4) with obscure lameness. It is a reliable method, but in case of multifocal uptake no definitive diagnosis can be made. A major disadvantage of scintigraphy is the limited access for routine use, since it is only provided in specialised centres.

Since both the flexion test and scintigraphy have their limitations, another helpful diagnostic application is necessary to define to localization of the lameness: intra-articular anaesthesia. In horses and men, intra-articular administration of a local anaesthetic is commonly performed for diagnostic purposes because of their simplicity, safety and low cost (5, 6). The principle is simple: local anaesthesia is injected into the joint, the anaesthetic is absorbed and sensation (including pain) in the area is temporarily blocked. As a consequence lameness decreases or even disappears, indicating the joint as the painful site. These interesting features encouraged us to investigate the possibilities of the technique in dogs. Since the application of IA for lameness diagnosis in the dog is poorly described, the data from human and equine medicine were collected as well as the data regarding the postoperative use of intra-articular anaesthesia in dogs.

Based on these data (chapter 1), the use, side effects and possible risks of intra-articular anaesthesia could be described. The practical use of diagnostic IA in the dog is in some aspects different from the use in men and horses. In horses intra-articular anaesthesia is applied in a systematic way to identify the source of lameness, while in dogs the most suspected joint is injected first, based on the history and clinical findings. Furthermore, lameness in horses is more often localized in the distal joints, which are easier to puncture even when there is little distension. The small canine joints do not allow an easy access and puncturing more than two joints is hardly tolerated by the dog. In horses nerve blocks can also be used to identify the source of lameness. The nerves serving the most commonly affected distal joints can easily be localized. Nerve blocks are not applicable in dogs because of the anatomic location of the nerves in the more proximal joints, where most orthopaedic problems occur in canine patients. In men intra-articular injections are used in many joints to differentiate the source of the problem within the painful joint, for instance in a chronically painful shoulder, wrist or ankle (7-9). It is also being used for the differentiation between hip and spinal pathology in cases of low back pain (10, 11) or for the evaluation of hip disorders prior to surgery to predict the surgical success (12). In other words, the painful region is not the main interesting item, but rather the involvement of the structures in the painful region. This is different from dogs, where the main problem is the identification of the painful site. Side effects (central nervous or cardiovascular system) are uncommon and are mainly the result from accidental intravascular injection rather than an overdose. In dogs we focus on the most suspected joint and, consequently, only a small volume of local anaesthetic is required, which makes overdosing and side effects very unlikely (13). The data from the literature allowed the determination of the safest product, the effective therapeutic dose to be applied in dogs as well as the determination of the toxic dose. Based on the data in men and horses and on the data regarding the postoperative use of intra-articular anaesthesia in dogs (14, 15), we could conclude that mepivacaine (Scandicaine 2%®, 20 mg/ml, AstraZeneca, Belgium) is the most appropriate product for diagnostic intra-articular anaesthesia in dogs: it has a fast onset of action and is a safe product, considering the successful use in the horse since many years (5). It can be administered at an effective dosage of 1.5 mg/kg, which is much lower than the

potential toxic dose (Table 1). With this dose, adverse effects are avoided, even when a second joint has to be punctured.

Anaesthetic drug	Relative potency*	Dose with epinephrine (mg/kg)	Dose without epinephrine (mg/kg)	Toxic dose (mg/kg)	Onset of action (minutes)	Duration of action (minutes)
Mepivacaine	2	7	5	29	5-10	120-150

Table 1 Onset time, duration of action, relative potency, clinical and toxic doses of mepivacaine for peripheral block procedures in dogs (14, 16).
*'Dose' refers to the intra-articular dose commonly used for pain relief in dogs. 'Toxic dose' is the IV dose that induces convulsions in dogs. *Potency is relative to procaine.*

Originally, the use of IA was thought to be impossible in dogs. Indeed, during several initial attempts, problems related to incorrect injection because of the small joint size in dogs were encountered and were probably related to the uncooperative behaviour of the dogs. Therefore proper restraint, either physically or under sedation, was the main condition to succeed in the intra-articular injection. On the other hand, the dog needed to walk before and after the intra-articular injection in order to evaluate the effect of local anaesthesia. The major concern was that sedation itself could interfere with the lameness evaluation because some sedative drugs have an analgesic effect of their own. Therefore, the effect of sedation on lameness should be known, before any further research on intra-articular anaesthesia could proceed (17).

The evaluation of two widely used sedation protocols for small animals (18, 19) and their possible effect on lameness was the first objective of this doctoral thesis (Chapter 3).

One protocol consisted of acepromazine (Placivet®, 20 mg/mL, Codifar, Belgium) and methadone (Mephenon®, 10 mg/mL, Denolin, Belgium) and is used for light to moderate sedation and analgesia. With this protocol the dogs were still able to walk, but needed more physical restraining. This type of sedation is only suitable for the more experienced surgeon, since the dogs can still react to painful punctures when entering the joint capsule or when the joint is extended while injection the local anaesthetic. The dose was based on body weight but also depended on the temperament of the dog, e.g. stressed dogs sometimes needed more sedation. In this study, three dogs needed a double dose (0.02 + 0.2 mg/kg) to allow manipulation or positioning on the table for intra-articular anaesthesia. However no different lameness grade was seen compared to dogs that received the lower dose (0.01 + 0.1 mg/kg).

The second protocol consisted of medetomidine ((Domitor, 1.0 mg/mL, Orion Pharma, Finland) dosage based on body surface area (BSA, using 500mcg/m^2)) and is indicated when heavy sedation is needed. The dog can be positioned on the table without extensive restraint, which is ideal in small practices. As lameness evaluation was not possible in heavily sedated dogs, the administration of an antidote with atipamezole, (Antisedan, 5.0 mg/mL, Orion Pharma, Finland), was needed to evaluate lameness after sedation. The dose of atipamezole was based on body surface area and can safely be increased to 5 times the medetomidine dose to efficiently antagonize the sedative effect of medetomidine within 3 to 7 minutes (20). The study proved that both sedation protocols were useful in lameness evaluation and can be used prior to intra-articular anaesthesia. In 12% of the dogs sedated with acepromazine plus methadone and in 20% sedated with medetomidine lameness increased with one grade after sedation. This was an unexpected finding. In a small number of dogs (8% in both groups), sedation did seem to decrease lameness with one grade. Based on this study we can conclude that in most cases, lameness is not eliminated by sedation and subsequent intra-articular anaesthesia can be performed and evaluated. We observed that, in some cases, lameness decreased minimally after sedation, but the difference was only one grade on a scale of 0 to 10 with each sedation protocol. Although the

observed variation is minimal, a change in lameness grade after intra-articular anaesthesia should be at least two grades on a scale of 0 to 10 to be significant, in order to be considered as a positive response.

The second objective of our research was to evaluate if intra-articular anaesthesia could be used in the dog under clinical conditions and which joints were indicated for this technique (Chapter 4). During a period of four years, all records of dogs with occult lameness or dogs in which localization of the lameness needed confirmation were evaluated.

The first conclusion was that IA was a feasible technique and can be applied in all joints, provided that the clinician is experienced in puncturing joints. In this respect, IA should be considered as an advanced technique. The shoulder and hip joint spaces are difficult to localize because of the large muscular layer. The carpal and tarsal joints are superficial and, although small, easily palpable. The elbow and stifle joints are more easy to puncture but often no synovial fluid is aspirated, necessitating the use of other means to confirm the intra-articular position.

The second conclusion was that all dogs needed sedation, no matter which joint was punctured. Because canine joints are not easy to puncture, immobilization of the dog is necessary not only to enter the joint but also to avoid iatrogenic damage. Therefore, one of the sedation protocols described in the first study was used.
The third conclusion was that a small number of false negative results were noted. This should be taken into account when lameness after IA is evaluated: a negative result does not exclude the punctured joint as the source of lameness. This finding is the main limitation of the technique.

The fourth conclusion was that the elbow joint is the main target joint for IA. Indeed, the elbow is the most common joint causing front limb lameness and medial coronoid disease is often a challenging disorder because of discrete clinical and radiographic changes (1). The contribution of IA is less frequently required for shoulder problems because of the clear clinical and radiographic lesions of the most common shoulder problem, which is OCD. However, in some cases shoulder lameness is very

challenging and IA can contribute to the further workup by confirming the shoulder as the problem site. Literature suggests that the most common sources of lameness that prove difficult to localize and definitively diagnose are the elbow and the shoulder joint. According to this study based on bilateral shoulder and elbow arthroscopy, preoperative localization and diagnosis of lameness based on examination, palpation and radiography was correct in 80% of the cases (21). These findings did not allow to determine which joint was primarily responsible for the lameness when both the shoulder and elbow had arthroscopic pathology. In those cases intra-articular anaesthesia could have been useful to identify exactly which joint is the source of pain in the front limb. In dogs with hind limb lameness, both the hip and stifle joints are commonly affected. Hip problems are easily diagnosed based on the clinical and radiographic findings. However, in some doubtful cases IA proved to be useful. Most stifle problems are caused by a ruptured cranial cruciate ligament and cause palpable instability and clear radiographic changes. The challenging cases are the stable joints with partial ruptures causing minimal clinical and radiographic changes. IA may also be useful in case of lameness after cruciate surgery or when stifle lesions are found in addition to other joint problems such as hip dysplasia. In contrast to the horse, the canine carpal and tarsal joints rarely require IA. Not only are these joints less frequently the cause of lameness problems, the localization of the carpus and tarsus are usually quite evident during the clinical examination.

Although this clinical study allowed us to draw conclusions about the possibilities and limitations of IA in different joints, it did not focus on the severity and type of lesions. This seemed especially interesting in the elbow joint because of the different appearances of medial coronoid lesions. Another aspect, which required further investigation, was the combination of IA with arthrography in the shoulder. Both themes were further elaborated in detailed studies.

As was demonstrated in the previous study, IA was often performed to indicate or confirm the elbow joint as the painful site. IA was applied in elbows with different disorders, but the most common diagnosis was medial coronoid disease. Medial coronoid disease (MCD) is characterized by different types of lesions of the medial coronoid process: chondromalacia, a fissure, a non-displaced fragment, a displaced

fragment and medial compartment disease. The coronoid lesion itself is often not visible on radiographs, but secondary signs such as osteophytosis and sclerosis may suggest the presence of a coronoid lesion. However, the more discrete lesions such as chondromalacia, fissures and non-displaced fragments often cause no or minimal secondary radiographic changes (1). Moreover, these lesions may also be present in adult and old dogs or uncommon breeds. In those cases the clinician might have some doubts and a confirmation of the lameness localization is desired. Therefore, we wanted to investigate if IA is also useful for these cases, in other words: can IA eliminate lameness caused by a fissure, chondromalacia or a non-displaced fragment.

In Chapter 5 our study included 90 dogs with confirmed MCD based on CT and arthroscopic findings. The affected elbow was injected at a dosage of 1.5 mg/kg of mepivacaine in the suspected elbow joint. This relative low dosage (2 ml for a medium-size dog) was sufficient to partially (minimum 2 grades on a scale of 0 to 10) eliminate pain in many dogs (78 out of 90 cases), without exceeding the recommended dose (5mg/kg). Additionally, this low dosage permits the injection of other joints in case of an unresponsive IA, bearing in mind that front limb lameness may be a diagnostic challenge. A positive effect on lameness was observed approximately 8 minutes after the intra-articular injection, which was in accordance with the onset of action described when mepivacaine is used for peripheral nerve blocks (Table 1). Although an improvement in lameness could be seen as soon as 2 minutes after injection it could also take up to 25 minutes in some dogs. This finding was also observed in horses, which reminds us of the importance of observing the patient over a sufficient period of time.

In our study the assessment of medial coronoid disease (MCD) was described as chondromalacia, fissuring or fragmentation (displaced or non displaced fragment) and medial compartment disease (erosions of medial coronoid process without clear fragmentation) on CT and arthroscopy. The differentiation of MCD in different types and their reaction on IA was of particular interest: some lesions, especially chondromalacia, fissures and non-displaced fragments, cause no or only minor radiographic changes. This finding makes localization and diagnosis of the problem difficult. IA was effective in all types of medial coronoid lesions though some lesions responded better than others. All non-displaced fragments and medial compartment disease showed a consistent positive response, but the effect of IA on chondromalacia, fissures and large displaced fragments were less predictable. In total the IA resulted in a positive outcome in 87% of the dogs. This implies that 13% of the dogs with confirmed elbow pathology did not respond to the intra-articular anaesthesia. This finding was also described in horses (5). A false negative test or the failure of intra-articular anaesthesia to reduce joint pain and lameness can have different explanations: the needle could have slipped out of the joint because of minimal motions during the procedure, the pain is originating from subchondral bone

with intact cartilage (chondromalacia, fissures) or the intra-articular damage is too severe (large displaced fragments).

To avoid false negative results a contrast medium (Iohexolum) could have been injected into the joint together with mepivacaine as was done in humans to confirm intra-articular position of the needle (22, 23). This was not done in our study because the extra volume would be too large for the small elbow joint, and additionally the contrast medium would interfere with following CT examination. Furthermore, it would necessitate an extra radiograph, which implied more radiation and more hassle, since the injection was not performed in the x-ray room, which was also being used for other patients. It should be remembered that this study was performed under clinical circumstances during the consultation hours.

It was concluded that lameness caused by medial coronoid lesions can often be decreased substantially, even in minimally affected joints. However, intra-articular anaesthesia can be false negative failing to indicate the elbow joint as the painful joint. In that case, other diagnostic tests are necessary. By using IA anaesthesia the diagnosis of MCD can be improved substantially, but unfortunately the disorder remains difficult to demonstrate in a small number of patients.

In Chapter 6 a combination of a contrast medium (iohexolum) and a local anaesthetic (mepivacaine 2%) in the shoulder joint is studied in analogy with its use in humans, known as anaesthetic arthrography (22, 23). The purpose of this study was to examine if arthrography, which is helpful to identify obscure shoulder problems, could be combined with IA without losing radiographic quality of the arthrography and with additional confirmation of the localization of the lameness. Moreover, this combination would avoid multiple punctures of the joint when both procedures are necessary. This study of 30 dogs with different shoulder pathology including OCD, biceps rupture, calcification of the caudal glenoid and infection, demonstrated that anaesthetic arthrography (AA) is a fast, noninvasive and efficient diagnostic tool to localize shoulder problems and provide additional diagnostic information with only one intervention. Similar as to the elbow joint, intra-articular anaesthesia was positive for the different lesions of the shoulder, but some lesions did not respond consistently. In 28 out of 30 dogs, the intra-articular injection had a positive effect. A positive effect on lameness was observed approximately 11 minutes after AA. This is somewhat slower than what was observed in the elbow. A reason could be that in the larger joint the anaesthetic needed more time to reach the lesion. Two dogs did not respond to the AA. In comparison with the elbow study 93% of the dogs responded positively. These better results could be explained because of the certainty of the intra-articular position or because of the different kind of lesions.

In conclusion we can state that AA of the shoulder improves the diagnosis of shoulder disorders by both localizing and identifying shoulder problems, provided that the surgeon has sufficient knowledge to interpret the arthrogram and bearing in mind the false negative result in a limited number of cases.

A limitation of this thesis is the applied visual scoring method for evaluating lameness instead of an objective measurement, more specifically a force plate or pressure plate (24, 25). However, we chose to use an 11-point numerical rating scale (NRS) (26), as this investigation was meant to be easily reproducible for clinical cases. It is known that subjective lameness evaluation is less reliable when performed by unexperienced veterinarians because of the intra-observer variation. In addition visual scoring should also be performed by the same individual because of inter-observer variation. In our

studies both types of variation were avoided by using different experienced observers, judging the animal directly and later on randomised video sequences. Furthermore, the used 11 point NRS system allowed detection of more subtle lameness changes than a typical 4- or 5-point scale (27). Moreover, the videotapes used in the different studies allowed the visualization of subtle changes in lameness by repeating the different sequences of the same dog.

If changes in lameness cannot be evaluated by direct visual observation, the method is not applicable under clinical circumstances. In this thesis, all studies were performed under clinical circumstances, which means that the dogs were examined as they were presented, with their owner and scheduled with other patients. The use of a force plate is very time consuming (28), which is not easily applicable when a large group of patients needs to be examined during the daily consulting hours. A recent study of the use of pressure plates in lame and non lame dogs suggests that pressure plate gait analysis may provide a practical alternative to force plates requiring fewer trials (24). This study also indicates that, in contrast with reports of discrepancies between human perception and objective force plate analysis, there is a good correlation between pressure plate kinetic asymmetry indices and visual gait assessment. These results also demonstrate that visual scoring, although subjective, is valuable.

In addition to previous disadvantages of force- and pressure plates, the gait of our dogs might have been unreliable or inconsistent, since the dogs needed to be sedated before intra-articular injection, which may not provide us with trustworthy evidence.

Another potential limitation of our experiments is the fact that two different sedation protocols were used prior to IA depending on the temperament of the dogs and a possible surgery on the same day. Dogs sedated with the medetomidine protocol and antidoted with atipamezole were not good candidates for a same day surgery. In Chapter 3 both sedation protocols were evaluated and no major differences between them were noted. Both sedation protocols could possibly decrease the lameness grade with one grade. The main difference between both sedation protocols is that sedation with acepromazine plus methadone has the advantage that dogs can be evaluated after sedation and before intra-articular anaesthesia is performed, which enables the

detection of subtle changes in lameness caused by the sedation. In the medetomidine group, dogs were not able to walk after sedation and therefore intra-articular anaesthesia could only be evaluated after antagonisation with atipamezole. Therefore, knowing that sedation can decrease lameness by one grade, intra-articular anaesthesia after sedation with medetomidine can be considered positive only when lameness has decreases by at least two grades on a scale of 10.

In conclusion, our studies have provided new insights into the validation and application of intra-articular anaesthesia of different joints in the dog. The major limitation of IA is the possibility of false negative results. Therefore it is important to confirm the intra-articular position of the needle by collecting synovial fluid or by easy injection and backflow of the local anaesthetic. In addition, the technique should be used with care and some experience in joint puncture is mandatory. Unfortunately, even when intra-articular position is confirmed, some lesions will not respond and if the painful joint could not be localized, further imaging methods such as scintigraphy, diagnostic ultrasound, contrast arthrography, computed tomography, magnetic resonance imaging and arthroscopy are necessary.

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SUMMARY

This study focuses on intra-articular anaesthesia as an aid to localize lameness in dogs. The literature about the use of intra-articular anaesthesia is reviewed in chapter 1. Following the aims in chapter 2, the possible analgesic effect of two widely used sedation protocols prior to intra-articular anaesthesia is discussed in chapter 3. The practical use of intra-articular anaesthesia in a large group of patients and the specific use in elbow and shoulder lameness are described in chapters 4, 5 and 6.

In **chapter 1** a review of the literature is given on the use of diagnostic intra-articular anaesthesia in horses and men and the available data regarding the postoperative use of intra-articular anaesthesia in dogs. Based on these data, the use, side effects and possible risks of intra-articular anaesthesia could be described. It was concluded that when intra-articular anaesthesia is performed in a sterile way and the correct dosage is used, little side effects are to be expected. Cardiovascular and central nervous system reactions are rare. In addition, in dogs only the most suspected joint would be injected, requiring only a small volume of local anaesthetic, which makes toxicity very unlikely. Mepivacaine (Scandicaine 2%®, 20 mg/ml, AstraZeneca, Belgium) proved to be the most appropriate product for diagnostic intra-articular anaesthesia in dogs because it has a fast onset of action (5 to 10 minutes) and it is a safe product, used for many decades in horses. It should be used at a dose of 1.5 mg/kg, which is much lower than the potential toxic dose. To allow intra-articular injection the dogs need to be sedated, but should be able to walk soon after the local anaesthetic is injected.

The scientific aims of this thesis are presented in **chapter 2**. The general aim was to validate intra-articular anaesthesia as diagnostic tool in obscure lameness in dogs.
The question rises if sedation necessary to allow intra-articular injection could influence the degree of lameness because of analgesic properties inherent to the sedative drugs and in such influence the interpretation of the intra-articular anaesthesia. Therefore in **chapter 3**, two sedation protocols (acepromazine + methadone and medetomidine) were evaluated on their influence on lameness. After sedation dogs were assigned into five groups: decreased lameness (> 1 degree), decreased lameness (< 1 degree), increased lameness (> 1 degree), increased lameness (< 1 degree), unchanged lameness. The scores were given by four observers on two

different occasions using a numerical rating scale- system from 0 to 10. In a small number of dogs (8% in both groups), sedation seemed to decrease lameness with one degree. In 12% of the dogs sedated with acepromazine plus methadone and in 20% sedated with medetomidine lameness surprisingly increased with one degree after sedation. In the other dogs lameness remained unchanged after sedation. We could conclude that in some cases lameness decreased minimally after sedation, but the difference was most frequently only one grade on a scale of 0 to 10 with each sedation protocol. For this reason intra-articular anaesthesia after sedation can be considered positive only when lameness has decreased by at least two grades on a scale of 10. The provided evidence allows clinicians to choose their preferred protocol for sedation prior to intra-articular anaesthesia.

To evaluate if intra-articular anaesthesia can be used in dogs under clinical circumstances, a group of patients collected over 4 years was analyzed. In **chapter 4** the approach of each joint is described and an overview of the different joints, the disorders and response to the intra-articular anesthesia are described. In this study a total of 190 dogs were injected in the most suspected joint with 1.5 mg/kg mepivacaine. Out of 190 injected joints, 166 responded with a temporarily amelioration of lameness (minimum 2 grades on a scale of 0 to 10). Six dogs were injected into the elbow joint with no amelioration of the lameness and the final diagnose was not an elbow problem (panosteitis (2), n. radialis paralyse, tumor of the scapula (2), OCD of the shoulder, fractured sesamoid bone). However 18 dogs had false negative results, meaning that the injected joint had confirmed pathology but the intra-articular anaesthesia had no effect. An overall conclusion is that diagnostic intra-articular anaesthesia can be performed safely in all joints and almost all lesions respond. However sometimes confirmed pathology does not respond and further diagnostic tools are necessary to confirm the painful joint.

In **chapter 5** the effect of intra-articular anaesthesia (IA) on lameness caused by medial coronoid disease (MCD) was assessed. MCD is represented by different types of pathologic lesions including chondromalacia, a fissure, fragment, and medial compartment disease and diagnosis is often difficult because of limited clinical and/or radiographic signs. The effect on the different types of MCD was investigated in 90

dogs presented with elbow lameness. The assignment of the type of lesion was based on computed tomography and arthroscopic findings. Out of 90 dogs injected with 1.5 mg/kg mepivacaine in the suspected elbow joint, 78 (87%) dogs had an improvement of lameness, which confirmed the elbow joint as primary cause of lameness. A positive response was seen in all types of medial coronoid lesions. A false negative result was observed in 12 dogs. IA was very effective in elbows with non-displaced fragments and medial compartment disease, but the effect of IA on chondromalacia, fissures and large displaced fragments was less predictable.

In **Chapter 6** the combination of intra-articular anaesthesia and arthrography of the shoulder was investigated. This technique called 'anaesthetic arthrography' is performed in humans to ensure the intra-articular location of the local anaesthetic. In this study 30 dogs with suspected shoulder pathology were injected with a combination of mepivacaine and iohexolum at a 1:1 ratio. The dilution of the contrast medium with local anaesthetic did not affect the quality of the images. In the majority of dogs arthrography gave extra diagnostic information and in combination with intra-articular anaesthesia helped to localize the painful shoulder as cause of the lameness. In 28 out of 30 dogs, the intra-articular injection had a positive effect. The definite diagnose was based on the arthroscopic findings.

The **final part** includes the general discussion and conclusions. All studies performed in the present Phd-thesis provided insights in the possibilities of intra-articular anaesthesia as diagnostic tool in obscure lameness in dogs in which clinical and radiographic examination did not enable the localization of the painful joint. The major limitation of intra-articular anaesthesia is the possibility of causing false negative results. In these cases alternative diagnostic methods such as scintigraphy, computed tomography, magnetic resonance imaging or arthroscopy will still be necessary to identify the source of lameness.

SAMENVATTING

Dit onderzoek is gericht op de toepassing van intra-articulaire anesthesie als een middel om de exacte lokalisatie van het manken in honden op te sporen. De literatuur met betrekking tot het gebruik van intra-articulaire anesthesie en de doelstellingen van het onderzoek worden beschreven in respectievelijk hoofdstuk 1 en 2. Hoofdstuk 3 beschrijft het mogelijke analgetisch effect van twee alom gebruikte sedatieprotocols vooraleer intra-articulaire anesthesie wordt toegepast. De praktische toepassingen van intra-articulaire anesthesie in een brede groep van patiënten en het specifiek gebruik in de elleboog en schouder worden beschreven in hoofdstukken 4, 5 en 6.

Hoofdstuk 1 geeft een volledig overzicht weer van de beschreven literatuur over het gebruik van intra-articulaire anesthesie voor de diagnose van manken bij paarden en mensen alsook een overzicht van de beschikbare gegevens met betrekking tot het post-operatief gebruik van intra-articulaire anesthesie bij honden. Op basis van deze gegevens beschrijven we het gebruik, de bijwerkingen en de potentiële risico's van deze techniek. We konden besluiten dat er weinig bijwerkingen te verwachten zijn indien intra-articulaire anesthesie wordt uitgevoerd op een steriele manier en met de aanbevolen dosissen. Bijwerkingen van het cardiovasculair systeem en het centraal zenuwstelsel zijn zeldzaam. Bovendien is het risico op toxiciteit minimaal vermits bij de hond een laag volume van het lokaal anestheticum worden geïnjecteerd in het meest verdachte gewricht. Het meest geschikte product voor intra-articulaire anesthesie bij honden is mepivacaine omdat het een snelle werking heeft (5 tot 10 min.) en het een veilig product betreft welke reeds tientallen jaren wordt gebruikt bij paarden. De aanbevolen dosis is 1.5 mg/kg welke veel lager is dan de potentiële toxische dosis.

De doelstellingen van dit onderzoek worden beschreven in **hoofdstuk 2**. De algemene doelstelling betreft de validering van intra-articulaire anesthesie als een middel voor de definitieve diagnose van manken bij honden waarvan de locatie onbekend blijkt na onderzoek via klassieke klinische en radiografische technieken.

De meeste honden moeten gesedeerd worden om een intra-articulaire injectie toe te laten maar moeten ook onmiddellijk na de injectie van het lokaal anestheticum terug

kunnen lopen om het effect na te gaan. Een van de prominente vragen welke zich stellen betreft de mogelijke invloed van sedatie op de graad van manken. Deze vraag stelt zich omdat de analgetische eigenschappen inherent aan sedativa, de interpretatie van de resultaten van de intra-articulaire anesthesie mogelijks zou kunnen beïnvloeden. Om deze vraag te beantwoorden werden twee sedatie protocols bestudeerd in **hoofdstuk 3** en hun invloed op het manken nagegaan: acepromazine plus methadone, en medetomidine. Honden werden ingedeeld in 5 groepen na sedatie: >1 graad verminderd manken, <1 graad verminderd manken, >1 graad vermeerderd manken, <1 graad vermeerderd manken, en onveranderd manken. De scores werden gegeven door vier ervaren clinici op twee verschillende tijdstippen op basis van een 'numerical rating scale' van 0 tot 10. Enerzijds verminderde het manken door sedatie met beide protocols met 1 graad in een kleine groep honden (8% in beide groepen). Anderzijds, vermeerderde het manken door sedatie met acepromazine plus methadone (12% van de groep) en medetomidine (20% van de groep) met 1 graad. Bij de overige honden bleef het manken onveranderd na sedatie. We konden dus vaststellen dat in enkele gevallen het manken was verminderd na sedatie maar dat het verschil beperkt bleef to t 1 graad voor beide protocols op een schaal van 0 tot 10. Hierdoor kunnen we besluiten dat intra-articulaire anesthesie na sedatie kan worden beschouwd als een positief resultaat wanneer het manken vermindert met ten minste 2 graden op een schaal van 0 tot 10. Deze vaststelling laat clinici toe te kiezen tussen beide sedatie protocols alvorens over te gaan tot intra-articulaire anesthesie.

Over een periode van vier jaar werden er gegevens van een groep patiënten verzameld en geanalyseerd om na te gaan of intra-articulaire anesthesie kan gebruikt worden bij honden onder klinische omstandigheden. In **hoofdstuk 4** beschrijven we het gebruik van deze techniek in elk type gewricht met een overzicht van de verschillende soorten gewrichten, de kenmerkende problemen en het resultaat van de intra-articulaire anesthesie. In dit onderzoek werden 190 honden geïnjecteerd in de verdachte gewrichten met 1.5 mg/kg mepivacaine. Een tijdelijke verbetering van het manken werd vastgesteld bij 166 van de 190 honden (minimum 2 graden op een schaal van 0 tot 10). Zes honden werden geïnjecteerd in de elleboog met geen verbetering van het manken tot gevolg maar de finale diagnose bevond zich dan ook niet in de elleboog (nl. panosteitis (2), n. radialis paralyse, tumor van de scapula (2), OCD van de

schouder, en een sesamoid beenfraktuur). Achttien honden hadden vals negatieve resultaten waarbij wel pathologie werd vastgesteld in de geïnjecteerde gewrichten. Op basis van deze resultaten konden we algemeen besluiten dat intra-articulaire anesthesie veilig kan worden toegepast in bijna alle types van problemen van de gewrichten. Soms echter reageert aanwezige pathologie vals negatief en zijn bijkomende diagnostische technieken nodig om uitsluitsel te geven over het pijnlijke gewricht.

In **hoofdstuk 5** onderzoeken we het effect van de intra-articulaire anesthesie op het manken welke veroorzaakt wordt door een losse processus coronoideus (LPC). LPC wordt gekarakteriseerd door verschillende type pathologie inclusief chondromalacia, fissuren, fragmenten en erosies van het mediale compartiment. Als gevolg van beperkte klinische en radiografische afwijkingen is de diagnose veelal moeilijk. Het effect van de intra-articulaire anesthesie op de verschillende types LPC werd onderzocht in 90 manke honden met elleboogproblemen. De finale diagnose van het type probleem werd achterhaald met computed tomografie en arthroscopie. Het manken verbeterde in 78 van de 90 honden (87%) na injectie met mepivacaine in het ellebooggewricht, waarbij de elleboog als primaire oorzaak van het manken werd bevestigd. Een positief signaal werd geobserveerd voor alle types van LPC maar ook vals negatieve resultaten werden vastgesteld bij 12 honden. Enerzijds zagen we een heel goede werking van de intra-articulaire anesthesie in ellebogen met niet-verplaatste fragmenten en erosies van het mediale compartiment. Anderzijds was het effect van de intra-articulaire anesthesie minder voorspelbaar bij chondromalacia, fissuren en grote verplaatste fragmenten.

In **hoofdstuk 6** onderzoeken we de combinatie van intra-articulaire anesthesie en arthrografie van de schouder bij honden. Deze techniek, “anesthetische arthrografie” genaamd, wordt reeds toegepast bij mensen om de juiste intra-articulaire positie van het lokaal anaestheticum na te gaan. Bij ons onderzoek werden 30 honden geïnjecteerd in het schoudergewricht verdacht voor pathologie. De honden werden geïnjecteerd met een combinatie van mepivacaine en iohexol in een 1:1 verhouding. De verdunning van het contrastmedium met het lokaal anestheticum had geen invloed op de kwaliteit van de beelden. Arthrografie gaf bijkomende diagnostische informatie

bij de meerderheid van de honden en was bovendien in combinatie met intra-articulaire anesthesie nuttig voor het lokaliseren van de pijnlijke schouder als oorzaak van het manken. De intra-articulaire injectie gaf een positief resultaat in 28 van de 30 honden waarbij de definitieve diagnose werd vastgesteld met arthroscopie.

In **hoofdstuk 7** wordt ten slotte het algemeen besluit gevormd met de nodige discussies. Het volledige onderzoek beschreven in deze doctoraatsthesis geeft aanwijzingen over de mogelijkheden van intra-articulaire anesthesie als nuttige techniek voor de diagnose van manke honden waarbij klassieke klinische en radiografische onderzoeken geen uitsluitsel kunnen vormen met betrekking tot de lokalisatie van het pijnlijke gewricht. Het grote nadeel van de intra-articulaire anesthesie zijn de mogelijke vals negatieve resultaten. Bij deze gevallen moeten we beroep doen op alternatieve diagnostische technieken zoals scintigrafie, computed tomografie, beeldvorming op basis van magnetische resonantie of arthroscopie, om de oorzaak van het manken te bepalen.

CURRICULUM VITAE

Delphine Van Vynckt werd geboren op 5 maart 1980 te Oostende. In 1998 behaalde zij het diploma middelbaar onderwijs aan het Sint Pieters Instituut te Gent. In 2004 behaalde zij het diploma van Dierenarts aan de Universiteit Gent.

Na het afstuderen bleef Delphine onmiddelijk verbonden aan de Vakgroep Medische Beeldvorming van de Huisdieren en Orthopedie van de Kleine Huisdieren op de dienst Orthopedie onder begeleiding van Prof. Dr. Bernadette Van Ryssen. Na een jaar internship Orthopedie bemachtigde ze in 2006 een Dehousse-beurs en startte ze haar doctoraatsjaren.

In 2009 onderbrak Delphine een jaar haar doctoraat om in San Francisco een roterende training te volgen in chirurgie.

In 2010 keerde zij terug naar de Universiteit Gent op de Vakgroep Medische Beeldvorming van de Huisdieren en Orthopedie van de Kleine Huisdieren en vanaf 2011 startte zij deeltijds als medewerkster in Dierenkliniek Drogenboom te Waregem waar zij zich toelegt op de orthopedische gevallen.

Delphine is auteur en mede-auteur van meer dan 10 wetenschappelijke publicaties in nationale en internationale tijdschriften.

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